TELESCOPE MAKING 31

ISSN 0190-5570

The magazine *for*, *by*, and *about* telescope makers!

Winter 1987/88

John Dobson at Stellafane

Telescope Making

The magazine *for*, *by*, and *about* telescope makers!

Editor: Richard Berry
Associate Editor: Robert E. Cox
Managing Editor: Stephen Cole

TELESCOPE MAKING (ISSN 0190-5570) is published quarterly by AstroMedia, a Division of Kalmbach Publishing Co., 1027 N. Seventh St., Milwaukee, WI 53233. Copyright (c) 1987 by Kalmbach Publishing Co., all rights reserved. Material in this publication may not be reproduced in any form without written permission. Second-class postage paid at Milwaukee, WI. POSTMASTER: Send address changes to TELESCOPE MAKING, 1027 N. Seventh St., Milwaukee, WI 53233. Direct editorial submissions to the address above, telephone (414) 272-2060. The opinions expressed in this magazine are not necessarily those of the publishers or editors. Not responsible for unsolicited materials. Names and address of authors will be printed unless specifically requested otherwise. Direct questions about subscriptions to (414) 272-2060. Subscription price (U.S.): one year $12; single issues $4; foreign: one year $14; single issues $4.50. Clubs and dealers: Inquire about bulk rates. Editorial Assistant: Kristine R. Majdacic; Art Assistant: Todd Graveline; Advertising: Dana-Lynne Terry. Printed by Port Publications, Port Washington, WI.

In this issue...

2 **Editorial**

4 **The Warren Rupp Observatory**
by Robert Bunge

12 **The OCA's Anza Observatory**
by John Sanford

20 **The Schalck-Newtonian**
by Robert Schalck

24 **A Test for Figuring Cassegrain Secondaries**
by Jordan D. Marche II

24 **Highlights of Stellafane 1987**
by Richard Berry

40 **Rolling Observatory**
by Tom Clark

44 **The Texas Star Party in 1987**
by David J. Eicher

50 **Optical Experts Comment on the TSP**
compiled by Robert E. Cox

56 **The Blue Pages**

Cover: John Dobson at Stellafane. Photo by Richard Berry.

Editorial

TM#31 is full of observatories--and observatories are often years in the making. I asked the folks in Ohio and California to write up their observatory-building experiences in the hope that their hard-earned expertise would prove useful to those just starting such projects now. It's a long road--but the payoff is great. For the individual, Tom Clark offers an alternative: a rolling observatory.

As soon as I get this issue out the door, I'm going to run a raytrace on Bob Schalck's new Newtonian design (page 20). It's not that I don't trust his analysis--but I'd really like to see the spot diagrams popping up on my own screen. With fast new color films like SR-V 3200 (see ASTRONOMY, November 1987), my old interest in deep-sky photography has rekindled.

I'll leave comments on the unique gathering of optics people at this year's Texas Star Party to Bob Cox. Bob really had to work on this one, but the result is a fascinating insight into the world of superfine optics. Let me know if you like it--it could become an annual feature.

Meanwhile, we've got a lot of good material lined up for TM#32. Dick Suiter put his analytical skills to the test: asking basic questions about paraboloidal mirrors. This article will be a must-read for everyone using a Newtonian. Ever since TM#30 came out, we've had a

flood of mail asking for more information about David Gedalia's Atari-controlled Dobsonian telescope. Although David is busy with his schoolwork, he has agreed to write up his control system for TM--so please hang on! We'll also be covering AstroFest in TM#32, Bob Cox has some interesting stuff up his sleeve about refractors, and there are lots of other goodies in the pipeline.

About six weeks ago Vic Menard of Tectron Telescopes sent a set of the firm's collimating tools for review in TM. If you've seen their ads, you already know they make a sight tube, a Cheshire eyepiece, and an autocollimating tool. You may also realize that TM doesn't have a regular review column. Well, that didn't stop me from trying these tools on my 6-inch f/5 photographic Newtonian and my 10-inch f/6 Dobsonian--and getting them significiantly better centered than they were before. The Tectron tools are machined from aluminum, black anodized, and very precise. Conclusion: an excellent product, and worth the price. Recommended.

Enough. The next TM will be in the mail on March 21, 1988. See you then.

--RLB

And from Bob Cox....

I've been attending telescope making meetings since 1936. Except for the early Stellafane gatherings, few amateur meetings have been graced by as many professional opticians as the 1987 Texas Star Party. The TSP also attracted a unique collection of specialized refracting and TCT telescopes. That both opticians and telescopes were present was no accident: each of the opticians knew the others planned to attend, and also that the telescopes would be present for evaluation.

One of my projects for this issue of Telescope Making was to collect and edit the comments from these optical experts. The story begins on page 50. It may offend some people, but it will delight others because it's really about optical quality. Superb optical performance should NOT be a rare treat for an elite few. Every amateur astronomer and every telescope maker deserves good optics.

A trend the professionals pointed out was the lack of high-quality commercial telescopes. Too few of the instruments being made today have optics good enough to satisfy a skilled observer's needs--though they may suffice for the average amateur. To some extent this problem stems from the need for portability, and that has been brought about by light pollution. But portability forces makers into compromises, and often those compromises result in lower optical quality. Sad to say, the average 12-inch f/8 reflector of twenty years ago was a far better all-around telescope than the f/4 to f/5 telescopes we see today--but it was a real beast, too big for portability. And an f/12 apochromat will outperform an f/8 instrument--other things being equal--but it isn't as compact. Too often, portability forces the amateur to choose between too much light pollution and too little optical quality.

Not surprisingly, the experts commented on the low percentage of amateur-made instruments present at the TSP. A couple of decades ago homebuilt scopes would have dominated--but things change and not always for the better. Nevertheless, a 5-percent turnout of homebuilt instruments is better than 4 percent--or even none! Making one's own first mirror is seldom easy, but a confirmed Telescope Nut will always go the extra mile and make the finest mirror he can.

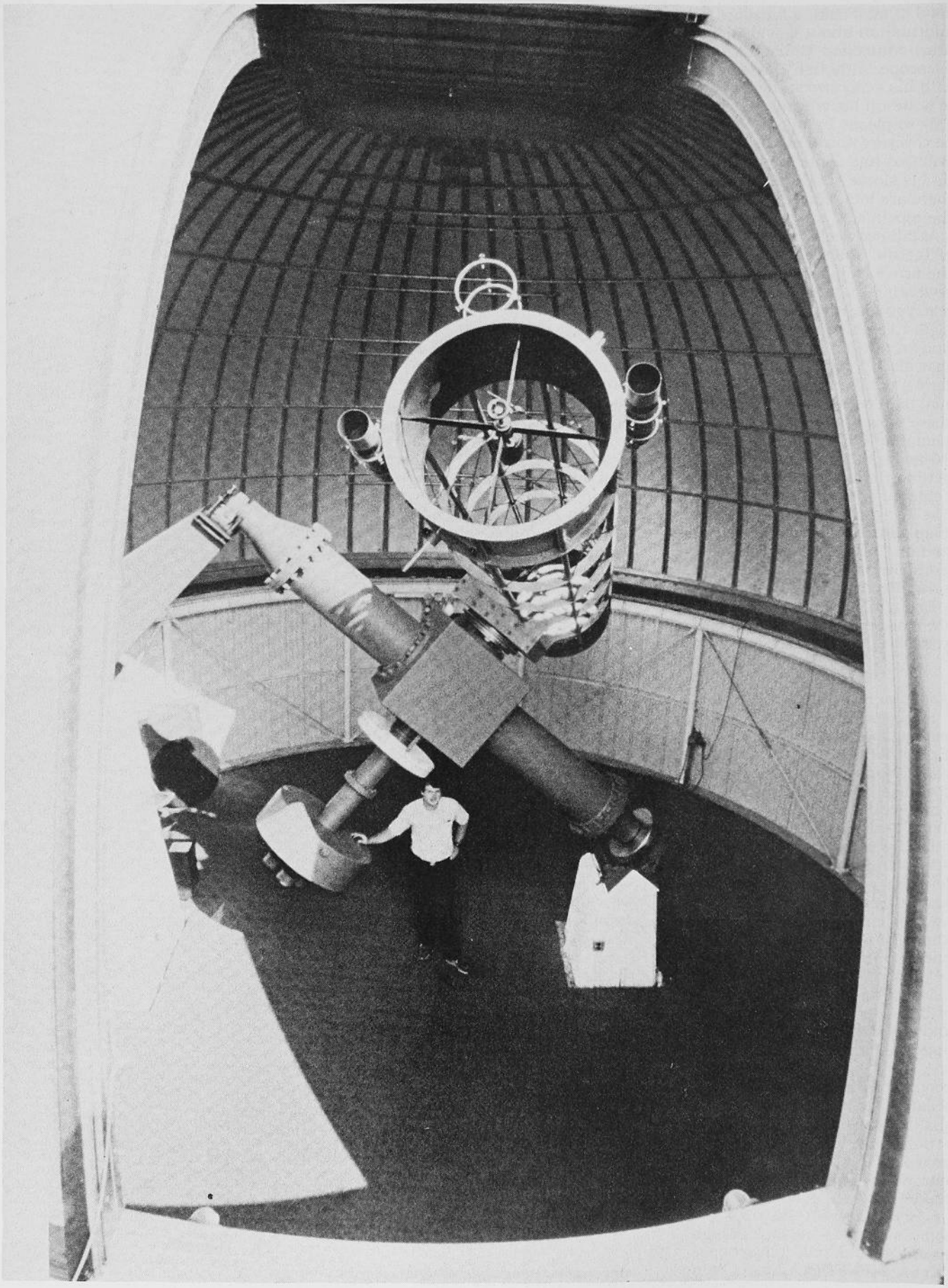
It is important to note that the optical experts who attended the TSP all said they would not have come if it were not for the special equipment they knew would be shown there. We need these people to come to our meetings. Dick Sumner's suggestion that a special area be set aside for displaying new and innovative optics and equipment is superb. I think that the ease of comparing and evaluating the new designs brought to the TSP makes this approach indispensable. Perhaps we could call these areas something inspiring like "Optics Alley" (Psst--Stellafane, Riverside, TSP, Astrofest--are you listening?)

Although I knew that the apos and the experts would be at the TSP, I was unable to attend. I will cry softly in my sleep for many months yet to come over missing it. However, I will try to get to any similar special party I hear about. Of that you can be sure.

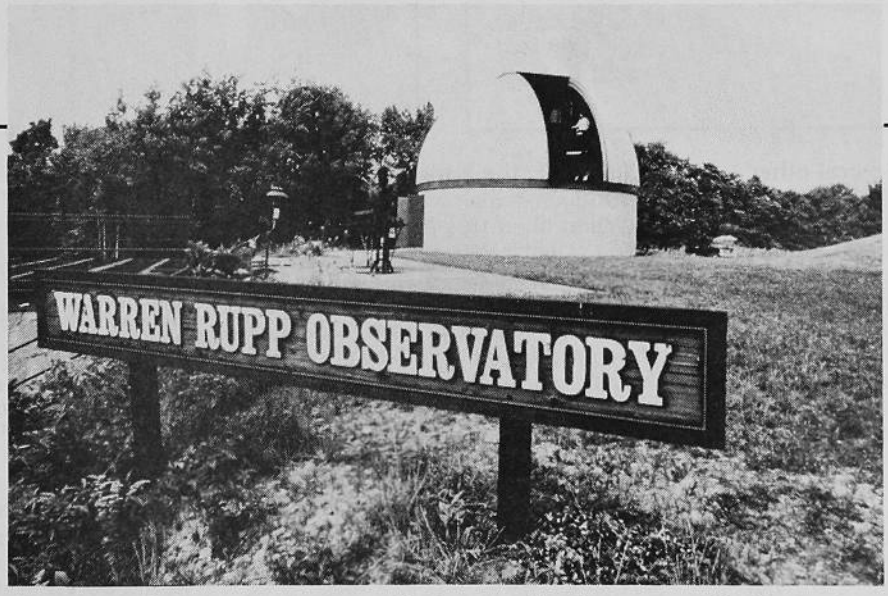
--R.E.C.

STATEMENT OF OWNERSHIP, MANAGEMENT, AND CIRCULATION

(Required by 39 U.S.C. 3685). 1A. Title of publication: Telescope Making. 1B. Publication No.: 685190. 2. Date of Filing: September 30, 1987. 3. Frequency of issue: Quarterly. 3A. Number of issues published annually: 4. 3B. Annual subscription price: $12.00. 4. Complete mailing address of known office of publication: 1027 N. 7th Street, Milwaukee, WI 53233-1471. 5. Complete mailing address of the headquarters or general business offices of publisher: Same. 6. Full names and mailing addresses of publisher, editor, and managing editor: Publisher, Robert A. Maas, 1027 N. 7th Street, Milwaukee, WI 53233-1471; Editor, Richard Berry, same address; Managing Editor, Stephen Cole, same address. 7. Owner: Kalmbach Publishing Co., 1027 N. 7th St., Milwaukee, WI 53233-1471; stockholders owning or holding 1 percent or more of total amount of stock are: William B. Calhoun, Jr., Box 2166, Estes Park, CO 80517; Estate of Drayton Cochran, c/o Wellington & Co., 120 Broadway, New York, NY 10005; Alexander L. H. Darragh, Route 8, Box 95, Harrison, AR 72601; George A. Gloff, 1027 N. 7th St., Milwaukee, WI 53233; Elizabeth K. Grunden, 10926 Leaning Ash Lane, Houston, TX 77079; Linda H. Hanson, 22154 Harbor Rd., Barrington, IL 60010; Robert L. Hayden, Jr., 1027 N. 7th Street, Milwaukee, WI 53233; Dr. H. W. Hein, 2549 S. Kinnickinnic Ave., Milwaukee, WI 53207; George F. Hirschmann Trust, 635 Glenridge Dr., Glenview, IL 60025; Margaret Jenkins, 2434 N. 102 St., Wauwatosa, WI 53226; Charles A. Kalmbach, 7435 N. Braeburn Lane, Glendale, WI 53209; Lois P. Kalmbach, 7435 N. Braeburn Lane, Glendale, WI 53209; William H. Kalmbach, 206 W. Johanna, Austin, TX 78704; James J. King, 1027 N. 7th St., Milwaukee, WI 53233; Kathryn Mahnke, 10006 La Placita Dr., Rancho Cordova, CA 95670; Ray J. Mertz, 10200 W. Bluemound Rd., #719, Wauwatosa, WI 53226; David P. Morgan, P.O. Box 702, Elm Grove WI 53122; Walter J. Mundschau, 1027 N. 7th St., Milwaukee, WI 53233; Norma &/or David B. Thornburgh, 5530 80th St., N., #C303, St. Petersburg, FL 33709. 8. Known bondholders, mortgages, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities: First Bank Milwaukee (N.A.), 201 W. Wisconsin Ave., Milwaukee, WI 53259-1000. 9. For completion by nonprofit organization authorized to mail at special rates (Section 423.12 DMM only): not applicable. 10. Extent and nature of circulation: 10A. Total number of copies printed (net press run): average number of copies each issue during preceding 12 months: 7,342; actual number of copies of single issue published nearest to filing date: 8,775; 10B. Paid and/or requested circulation: 10B1. Sales through dealers and carriers, street vendors, and counter sales: average number of copies each issue published nearest to filing date: 552; actual number of copies of single issue published nearest to filing date: 560. 10B2. Mail subscription (paid and/or requested): average number of copies each issue during preceding 12 months: 5,339; actual number of copies of single issue published nearest to filing date: 6,336. 10C. Total paid and/requested circulation (sum of B1 and B2): average number of copies each issue during preceding 12 months: 5,891; actual number of copies of single issue published nearest to filing date: 6,896. 10D. Free distribution by mail, carrier, or other means of samples, complimentary, and other free copies: average number of copies each issue during preceding 12 months: 45; actual number of copies of single issue published nearest to filing date: 46; 10E. Total distribution (sum of C and D): average number of copies each issue during preceding 12 months: 5,936; actual number of copies of single issue published nearest to filing date: 6,942. 10F. Copies not distributed: 10F1. Office use, left over, unaccounted, spoiled after printing: average number of copies each issue during preceding 12 months: 1,318; actual number of copies of single issue published nearest to filing date: 1,741. 10F2. Return from news agents: average number of copies each issue during preceding 12 months: 88; actual number of copies of single issue published nearest to filing date: 92. 10G. Total (sum of E, F1 and 2 should equal net press run shown in A): average number of copies each issue during preceding 12 months: 7,342; actual number of copies of single issue published nearest to filing date: 8,775. 11. I certify that the statements made by me above are correct and complete. Sharon M. Drobinski, Office Manager.



The Warren Rupp Observatory



Looking into the open dome from the east, we see the 31-inch f/7 Newtonian telescope on its massive English mounting. The photo was taken from the Mite-E-Lift observing platform.

Doug Wereb could not believe his ears. Sitting over an anchovy pizza in Cleveland, Norm Oberly and Jim Thomas were calmly discussing the biggest project of their lives. A teenager, Wereb was happy to sit in the corner and listen to his mirror making teacher, Oberly, debate the project. "If we can only get a blank, we'll be on the way!" Unknown to anyone at that table, fifteen years later, Wereb would supply the last vital contact needed to finish the 31-inch f/7 telescope at Warren Rupp Observatory.

Now operated by the Richland Astronomical Society (Richland County, Ohio),the 31-inch Newtonian reflector may be the largest amateur-run telescope in the United States. The telescope sits in a large AshDome on a cross-axis English mount. Because the eyepiece can reach a height of thirty feet off the dome floor when the telescope is pointed at the zenith, a Mite-E-Lift hydraulic platform serves as the observing chair.

Under dark skies twenty miles south of Mansfield at the Hidden Hollow Camp, the 31-inch telescope is now the prime attraction of an observing site that already had a lot to offer. Mansfield is ideally located for Central and Northern Ohio Amateurs. The clubhouse provides a warm room to rest up before the drive home, and the camp offers rest rooms, cabins, a lodge, and meeting facilities.

Back in the sixties, Norm Oberly taught a TM class at a local school. Each of Oberly's students made the telescope from the blank up. Over the years Oberly had figured and tested hundreds of mirrors. That now-famous anchovy pizza of 1967 was the start of a fifteen-year project.

Amateurs living in Cleveland often had glimpses though a 36" telescope belonging to Case Western Reserve University, so they knew what a scope of that size could show. They wanted to build a large visual instrument for the public and amateur. Thus Oberly,

RICHLAND ASTRONOMY SOCIETY
MANSFIELD, OHIO

March 23, 1982

Mr. Warren Rupp
1627 Alta West Road
Mansfield, Ohio 44904

Dear Warren:

The Richland Astronomy Society has recently experienced an upswing in interest and membership. Several members in the club are very experienced in Astrophotography, Supernovae Patroling, telescope building, and locating deep sky objects. These talents are rubbing off on many other RAS members.

To further generate additional interest, a telescope builder has expressed his desire to locate his 31" f/7 telescope at our Hidden Hollow Observatory. The skies there are the darkest in Ohio and such a telescope would be the largest amateur-operated telescope in Ohio and possibly the world.

The telescope will be donated if we can house it in a new building. Mr. Dillon, Director of the Friendly House, has no objection to the idea and wants to provide any assistance possible. The cost needed to build such a building is estimated to be $6,000 to $7,000. RAS is now looking for patrons to donate money towards this project. We currently have approximately $2,000.

This new observatory will carry names in honor of those most responsible for its completion. If you or anyone you might know would be interested in donating to RAS, it would be most appreciated. All contributions to RAS are tax deductible.

Please, do not hesitate to give me a call if you have further questions. All donations are to be sent to the below address, made payable to Richland Astronomy Society.

Thank you,
Bruce Scodova
Bruce Scodova
President-Richland Astronomy Society

840 Hollywood Lane
Mansfield, Ohio 44907
756-4574 (Home)
522-1111 (Work)

OBSERVATORY · HIDDEN HOLLOW CAMP
POSSUM RUN ROAD
MANSFIELD, OHIO

THE WARREN RUPP COMPANY · ORIGINATORS IN PUMPING

Phone: (419) 524-8388
Telex: 987-458

THE WARREN RUPP COMPANY • P. O. BOX 1568, MANSFIELD, OHIO 44901
SHIPPING ADDRESS: 800 N. MAIN ST., MANSFIELD, OHIO 44905

March 29, 1982

Mr. Bruce Scodova
President
Richland Astronomy Society
840 Hollywood Lane
Mansfield, OH 44907

Dear Bruce:

The thought of our having the use of a 31" telescope here in our backyard is great news. You speak of the cost of housing the telescope would be between $6,000 and $7,000. You already have $2,000 in hand.

For the remaining $5,000, I offer to match dollar for dollar the $2,500 needed to complete the project. You can advise the other members and anyone else in the community that wishes to contribute.

Sincerely,
Warren
Warren E. Rupp

WER:j

Sucess! The Richland Astronomical Society's fund-raising letter to Warren Rupp, and Mr. Rupp's positive response, offering to match dollar-for-dollar contributions from other donors. Like Lick and Yerkes, Rupp ultimately provided the bulk of the funds for the instrument named after him. Right: Sunset--and an observer looks at Venus through the long, big reflector. The instrument was designed for top-notch visual performance, and so was constructed with a focal ratio of f/7.

Jim Thomas, and several other friends formed the Lake Erie Astronomical Project--LEAP--as a non-profit organization expressly to build a large scope. (Oberly and Thomas did not believe that an astronomy club could undertake such a large project and survive.) Once the scope was built, LEAP would turn it over to a club that could house and support it.

The first step was to locate a mirror. When they found out that General Electric was trying to get into the fused quartz mirror blank casting business at a Cleveland factory, LEAP members started working on G.E. "With all his zeal, Norm went in and explained the idea to the people at G.E.," says Thomas. They came up with a straight flush. It just so happened that G.E. had some extra blanks and was looking for a chance to write them off. One of the extras was a finely finished 31-inch blank that had been cast and shipped out to Kitt Peak for use on the McMath Solar Telescope as an optical flat. A design change in the McMath instrument had altered the specifications, and the blank was no longer needed. Shipped back to Cleveland, the 3-inch-thick, 235-pound glass disk was LEAP's.

When all of this happened in 1971, Oberly set up shop at his farm south of Cleveland. Known as the "LEAP site," it was there that Thomas spent hours roughing out, fine grinding and polishing the mirror. About this time, it was decided to make the telescope a Newtonian with a focal ratio of f/7. The decision-makers wanted a telescope that would be multi-purpose--not just a light bucket. With a small diagonal mirror and a coma-minimizing focal ratio, the scope would be good on both deep-sky and planetary observing.

In 1973 Oberly purchased a farm in North Royalton, a suburb of Cleveland. The polished mirror followed. That fall, aided by Jim Thomas, he started the task of figuring using subdiameter 10-inch and 16-inch tools. Testing the figure involved putting the mirror in a box on wheels, rolling it outside to the backyard, setting up the tester, and making a series of zonal readings.

Cleveland is not known for its mild winters. Troubled by the thought of the temperature differences to come and spurred by the idea of the almost-expansion-free quartz, Oberly decided to see what a large thermal difference would do. He watched through the tester as Thomas poured boiling water over the mirror. Afterward, he said "I saw black clouds of rising steam [in the tester, but] the figure did not change the slightest bit!" Even after that test, they wanted to make a final set of good readings more carefully than could be done outdoors. The local school hallway was the answer. Set up over Thanksgiving holiday, the mirror and tester sat for two days with the heat vents in the area turned off. Finally on the third day, they tested. "It looked like a 6 or 8 inch mirror that was six feet away, one with a very smooth surface."

MITE E LIFT LIFT A LOFT

The test showed the mirror to be parabolic within 1/12 wave. Its focal length is 213.62 inches. Norm drove the mirror to Brakenridge, Pennsylvania, where it was coated by Liberty Mirrors free of charge.

In 1974, the finished mirror was mounted and saw first light. Long before Dobsonians were known in Ohio, Oberly and company fiberglassed a Sonotube inside and out. Mounted on an alt-azimuth fork made of 4-inch pipe. the massive scope could not even reach zenith. LEAP built a fifteen-foot ladder to reach the eyepiece. This was all in Oberly's front yard, under a large tarp!

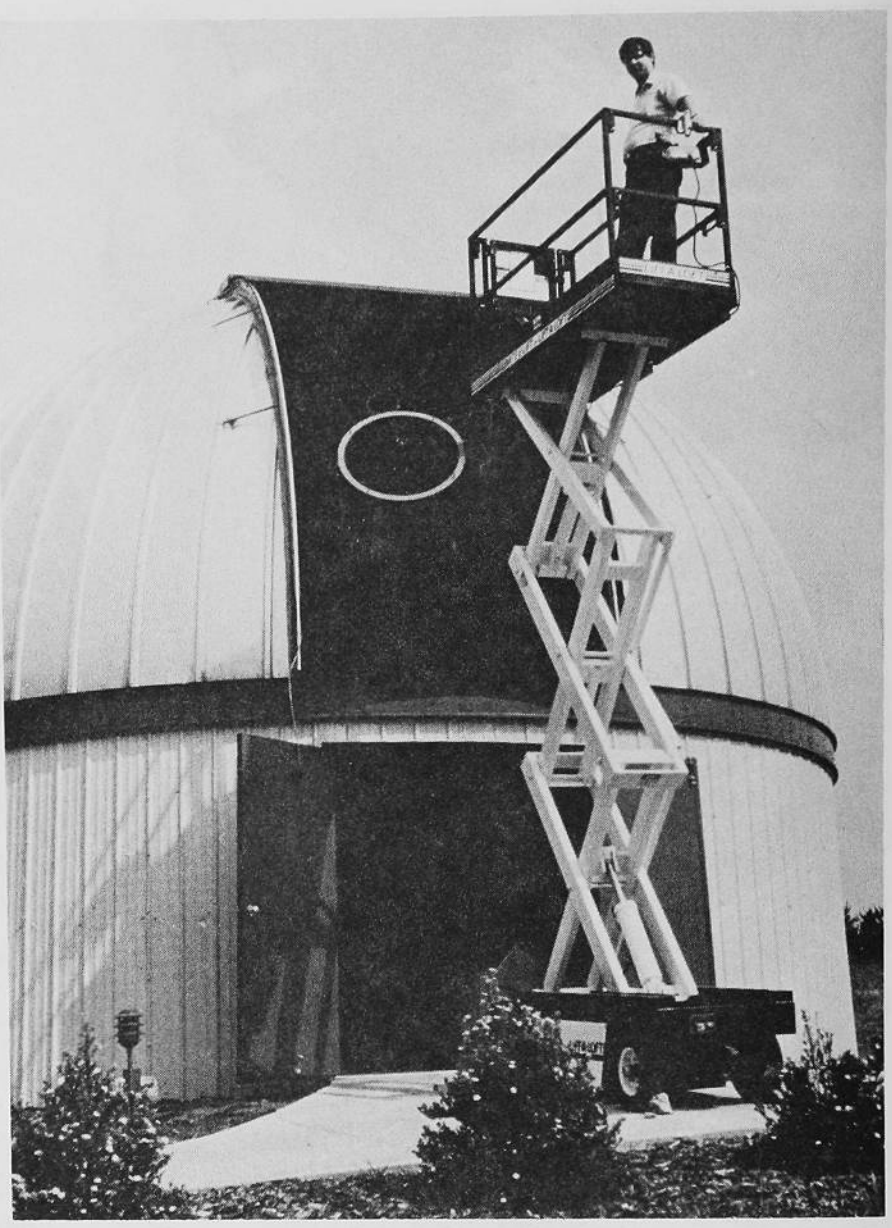
It was not an easy scope to use, but standing at the top of the ladder looking at M-13 was something akin to ahh, well....well SOMETHING! The scope saw use on many clear nights. But the difference between the expansion of the cardboard and fiberglass caused the tube to sag. The scope had to be torn down and the mirror stored in Oberly's garage.

Soon after the 31-inch was put in storage, an unplanned series of events started to unfold ninety miles to the south in Columbus, Ohio. At Ohio State University, the newly formed OSU astronomy club (OSUAC) and the Columbus Astronomical Society had become very active and interesting groups. Both clubs had been observing from light-polluted Perkins Observatory with a 32-inch telescope.

Access to the 32-inch was provided to the amateurs by none other than Doug Wereb, then an observing assistant at Perkins, on nights that conditions did not allow the 32-inch to be used for research.

Meanwhile, one of the OSUAC members, Bruce Scodova from Mansfield, had recently purchased a 12-inch scope. It was nice at Perkins, but Scodova and others yearned for darker skies. Scodova, along with OSUAC members Brent Archinal and Mark Mattox, found the Richland Astronomical Society at Hidden Hollow had a great site, but the club had all but ceased to exist.

It did not take long for the Hidden Hollow site to take over as the primary observing site for OSUAC and CAS, even though it was a long drive. But the introduction of new blood into RAS caused the club to become once again active. Sometime in 1980,



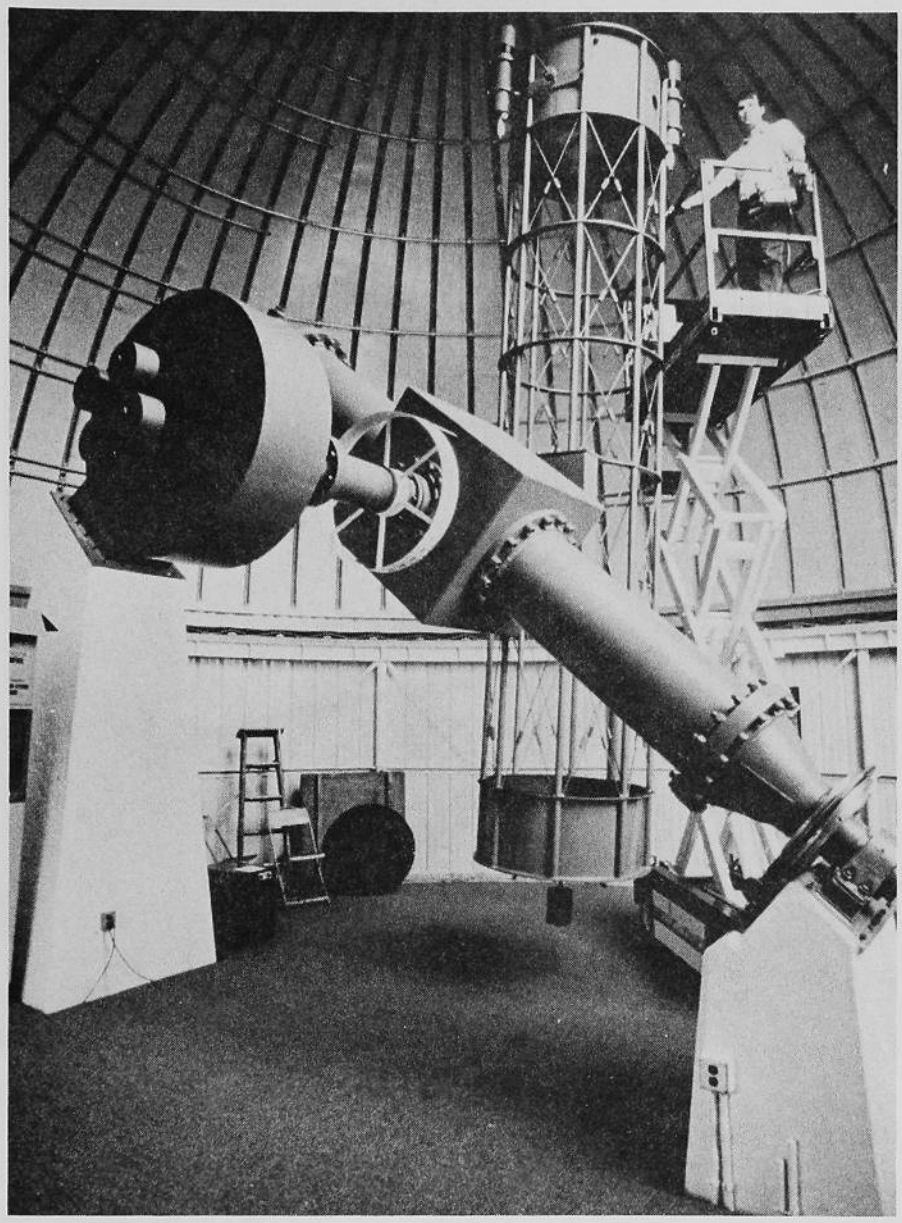
Outside the dome, the Mite-E-Lift shows its stuff. Brent Archinal mans the controls. The mobile observing platform is necessary for effective use of this unusually large amateur instrument.

Doug Wereb told Norm Oberly about Hidden Hollow, and managed to connect Oberly and Scodova. Everyone in LEAP and RAS liked the idea, but only one thing was lacking -- money!

Scodova and Oberly both had some form of alt-azimuth mount in a simple roll-off building in mind. Rough estimates put the cost at six to seven thousand dollars. RAS had about $2,000 in the bank, so in March of 1982 Scodova wrote a letter to Warren Rupp, an area industrialist. Rupp offered $2,500 if the club could find someone else to match it. RAS members wrote to local businesses and the Richland County Foundation, and in October the Foundation accepted Rupp's challenge and sent a check for another $2,500.

Meanwhile, Rupp had gotten bigger ideas. Long interested in astronomy, he knew the needs of an observatory. Meanwhile, with some money in hand, Scodova had plans and blueprints drawn up. In May of 1983, Scodova had a meeting with Rupp to show him the blueprints. Rupp looked over the plans, turned to Scodova and told him, "Make it a professional job. I want a big Ash Dome and everything."

Right away, the plans for the roll off were dropped, and a search for a professional engineer and



Pointed straight at the zenith, the 31-inch is a tall telescope. A picture of the same optical system, in a different tube and simpler mounting, appears on the back cover of Telescope Making #13.

builder got underway. RAS member Chris Coteff had heard of a firm in Cleveland, Dobbins Instruments, that built custom telescopes. In turn, Dobbins Instruments' Tom Dobbins located Gary Kader, of North Coast Engineering, for the design work. With help from Cleveland amateur Paul Leopold, they started the design process.

The big meeting was held on February 9, 1984. Everyone was there. Oberly, Thomas, Scodova, Kader, and Dobbins met with Rupp to get final approval. Rupp agreed to fund the project, and work got underway.

Bernard Dillion, the director of Hidden Hollow Camp, did not know what to make of it. Overnight he had become overseer to a REALLY large project. But with Dillion's help, Innovative Builders of Mansfield landscaped the site, poured the concrete floors and piers, and raised the supporting walls. The folks from Ash Dome arrived, and assembled the huge dome in one day! Electrical work and red lighting were supplied and installed by Kahls Electric.

Meanwhile the telescope slowly took shape in Cleveland. When it was finally done, it was disassembled and transported to the site. On a hot summer day in 1985, a crane lifted the big polar axis into place, but it soon became apparent that the south pier had been cut at the wrong angle! A few days later the pier had been fixed, and within hours the scope was in place.

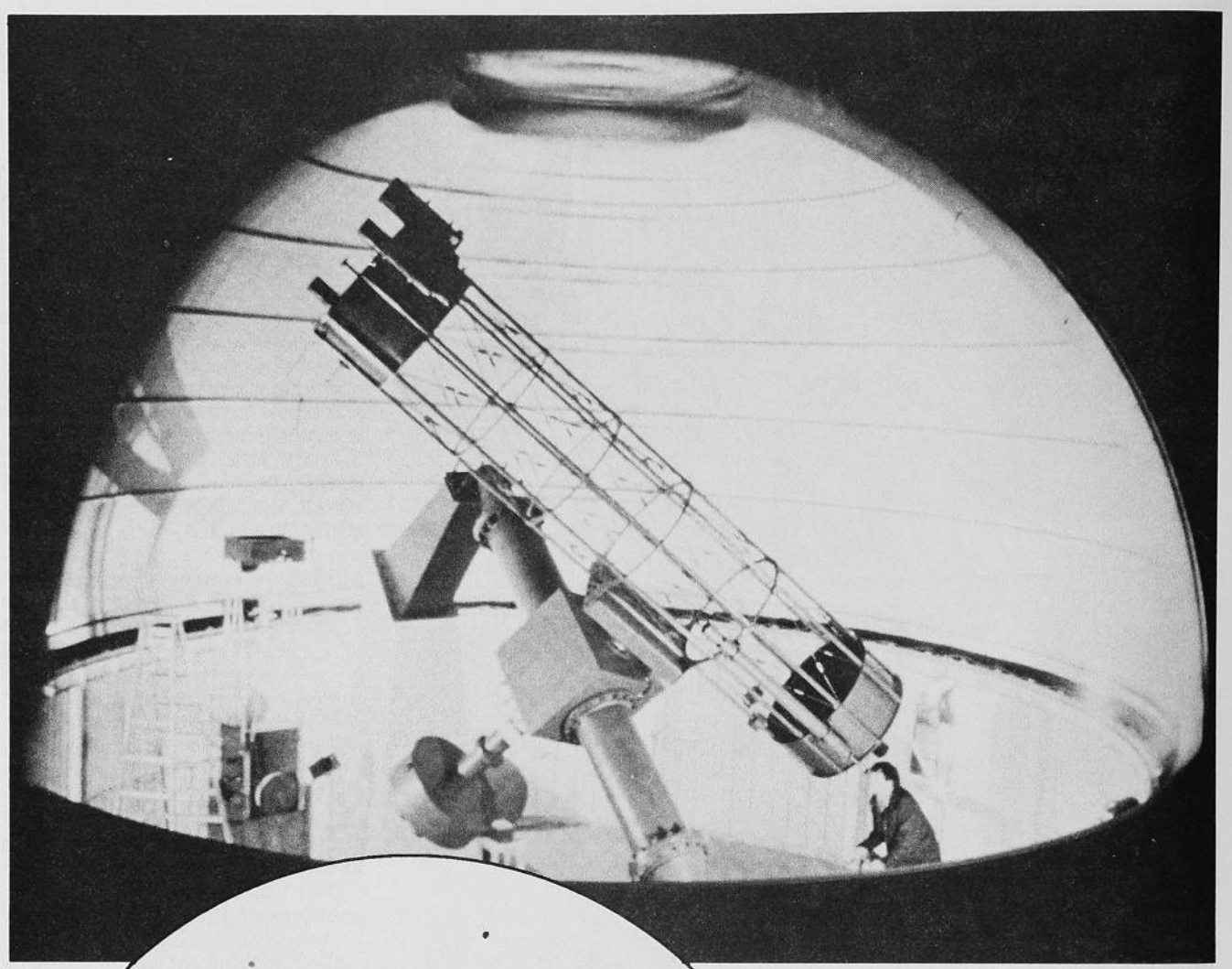
In mid September, a pack of astronomers arrived from Columbus. They set up telescopes in the shadow of the big dome. John Kerns wandered over and looked in the door at the assembled scope. He noticed something new. It was a brand new shiny Mite-E-Lift hydraulic platform. Yep, the keys were in it, and now was as good as anytime to learn how to drive it. Within a few minutes everyone in the area had been attracted by the new sound coming from inside the dome.

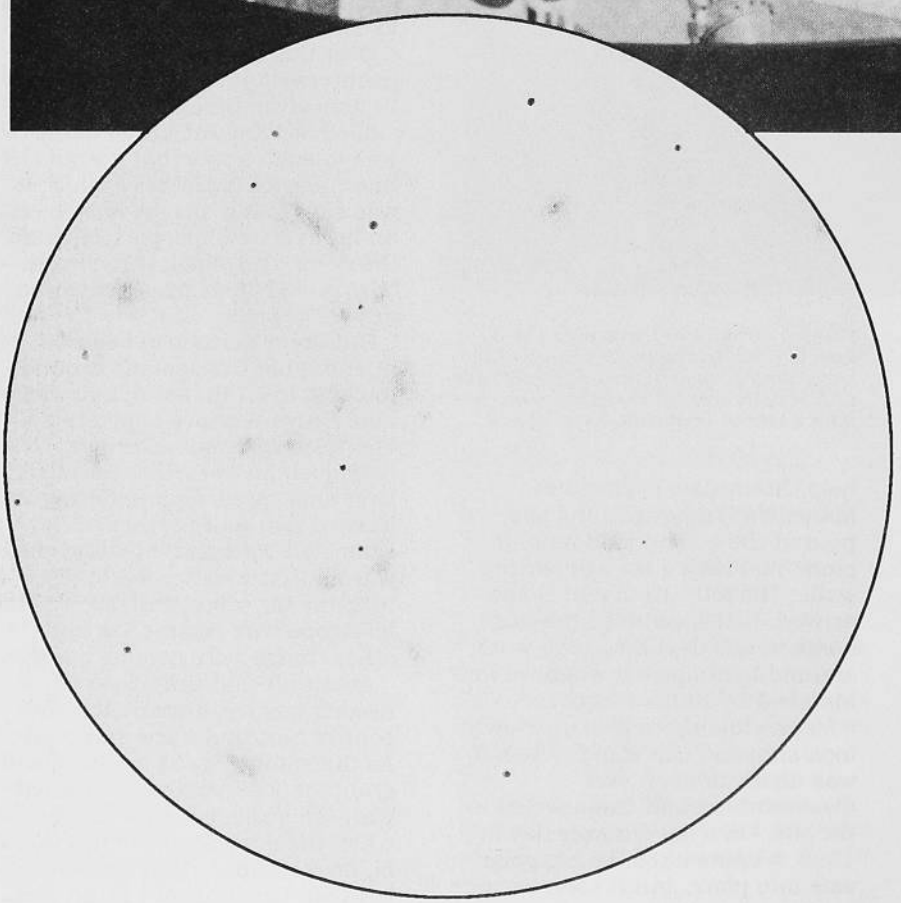
Well, the Mite-E-Lift worked, the dome slit opened, and the optics were in the scope and collimated. All that was missing was several tons of counterweights! The huge scope was literally tied to the walls of the observatory with ropes. With great care, they raised the lift under the fixed eyepiece, opened the slit, and they were on the way up. It focused! Kerns suddenly discovered what happens when you are the only Mite-E-lift driver in sight: for the next half hour he shuffled curious amateurs up for a look at faint stars drifting by.

Over the next several weeks, the counterweighting was worked out. In almost no time Kerns became skilled at tying the scope to the wall in such a way that it would let him track an object for a while. It was slow going, maybe one object an hour. A lot of people looked in the dome and shook their heads, "Using a 31-inch scope without a drive? No way!"

But John Kerns had been pushing big Dobsonians around too long to let that stop him. Before long Bruce Scodova joined him. The telescope was getting balanced, an operation that took a long time. Scodova and Kerns learned that a heavy duty extension cord and a folding chair was all that was needed to fine-tune the big scope. But, even as the telescope was coming together, other things were coming apart.

About all that the telescope needed was the drive motor, the control box, and a few accessories. As the summer wore on, the small group of observers who wrestled with the scope began to wonder when the drive and clutches would be hooked up. A disagreement between Dobbins and Rupp over



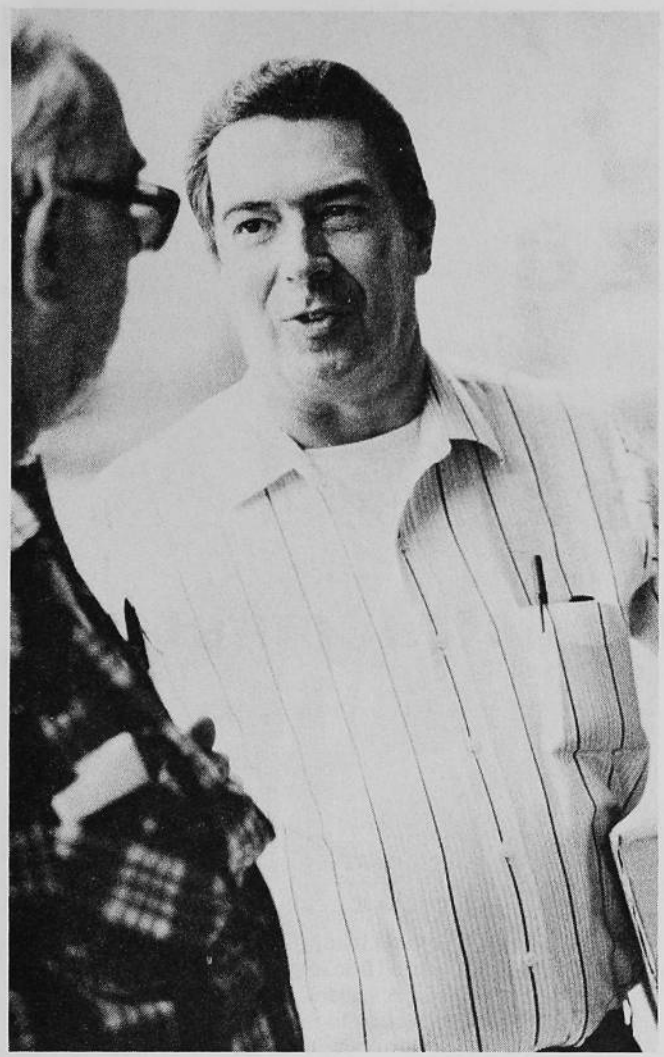


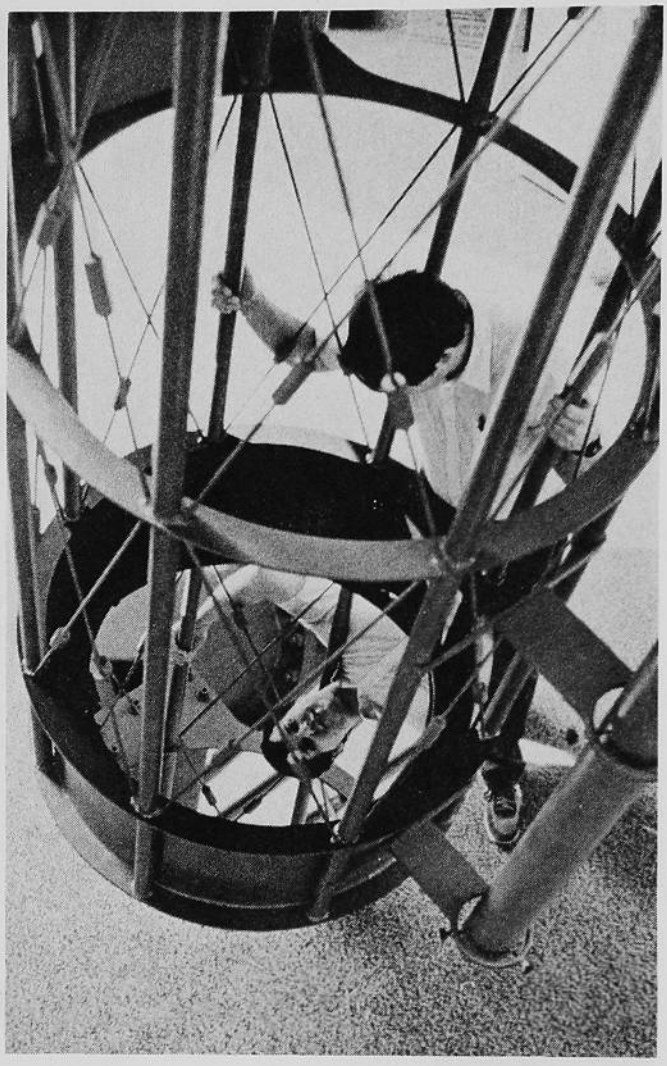
"X-ray" view of the 31-inch in its dome, taken from the Mite-E-Lift. (Note the 20-inch Dobsonian in the background in the dome.) Left: Abell 1367 observed by Robert Bunge at 171x in March 1987.

payment had left Dobbins with too little money to finish the work.

So in the end, RAS member Barrie McConnell along with Scodova spent most of the last half of the summer adjusting the clutches and installing the worm gears. Scodova and McConnell drove up to Cleveland and were given the remaining parts. They got the drive installed just in time for an Ohio Turnpike Amateur Astronomers (OTAA) meeting at the observatory. Even though it rained the whole time, amateurs from all across northern Ohio saw their new scope.

At the Intersection of I-71 and I-76 north of Mansfield is a Union 76 truck stop. On a cold Ohio winter day a group of amateur astronomers met to organize





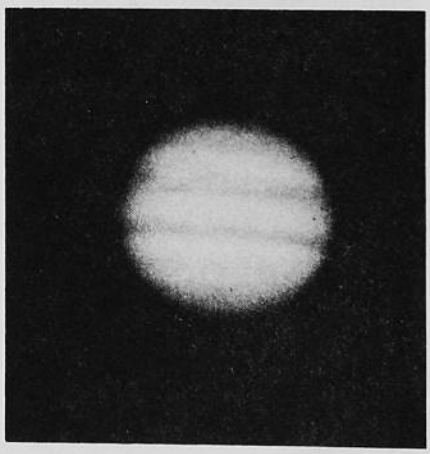
Hidden Hollow 87. As they sat around the table, some were eating dinner, others eating breakfast (it's a sin not to eat breakfast at a truck stop!). But someone from each of the major clubs in OTAA was present, and Hidden Hollow 87 was to be the first overnight convention held at the Warren Rupp Observatory.

On May 30, 1987, amateurs from all across Ohio lined up for a look in the eyepiece of the 31-inch. The next day, they listened to speakers from OSU and NASA's Lewis Research center. Finally Norm Oberly talked about the making of the mirror. At the end of his talk, Norm Oberly could only smile as the entire room broke into applause and gave him a standing ovation. After twenty years, the anchovies had finally been delivered.

The author wishes to thank the following for providing the background information for this article: Norm Oberly, Jim Thomas, Doug Wereb, Bruce Scodova, Paul Leopold, Brent Archinal,Tom Dobbins, Bernard Dillion, and Dawn Jenkins These amateur groups have been involved in the Warren Rupp Observatory: the Ohio State University Astronomy Club (OSUAC), the Richland Astronomical Society (RAS), the Columbus Astronomical Society (CAS), the Lake Erie Astronomical Project (LEAP), and the Ohio Turnpike Amateur Astronomers (OTAA), a unique club of astronomy clubs across Northern and Central Ohio. The road was long and the climb was high, but Norm Oberly's dream is now a reality.

Robert Bunge
110-1/2 Wilbur Ave.
Columbus, Oh. 43215

Above left: Norm Oberly at the Hidden Hollow meeting in 1987. Above right: Brent Archinal reflected in the primary mirror. Right: Jupiter in the 31-inch, shot with a 1/30-second exposure.



Robert Bunge and Dawn Jenkins recently informed TM that Warren Rupp passed away on October 14, 1987, after a long illness. The Richland Astronomical Society and all amateur astronomers in northern Ohio are saddened by the loss of their greatest benefactor. Mr. Rupp had visited the completed observatory only once.

Anza Observatory

The Orange County Astronomers

Back in 1970, Bob Goff, president of the Orange County Amateur Astronomers Association (as we were then known), proposed that our forty-five member club build and operate a major amateur observatory with a large telescope. Some fourteen years later, in September 1984, Bob's confidence and vision culminated in the opening of the Anza Observatory.

Located at a high and fairly dark desert site near Anza, California, the observatory features an equatorially mounted 22-inch (55cm) Cassegrain telescope. Although we thought it would be the second-largest amateur telescope in California when we planned it, the Dobsonian revolution came while it was being built. Nonetheless, the observatory, equipped with electronic and photographic accessories, ranks among the best amateur astronomical facilities in the country.

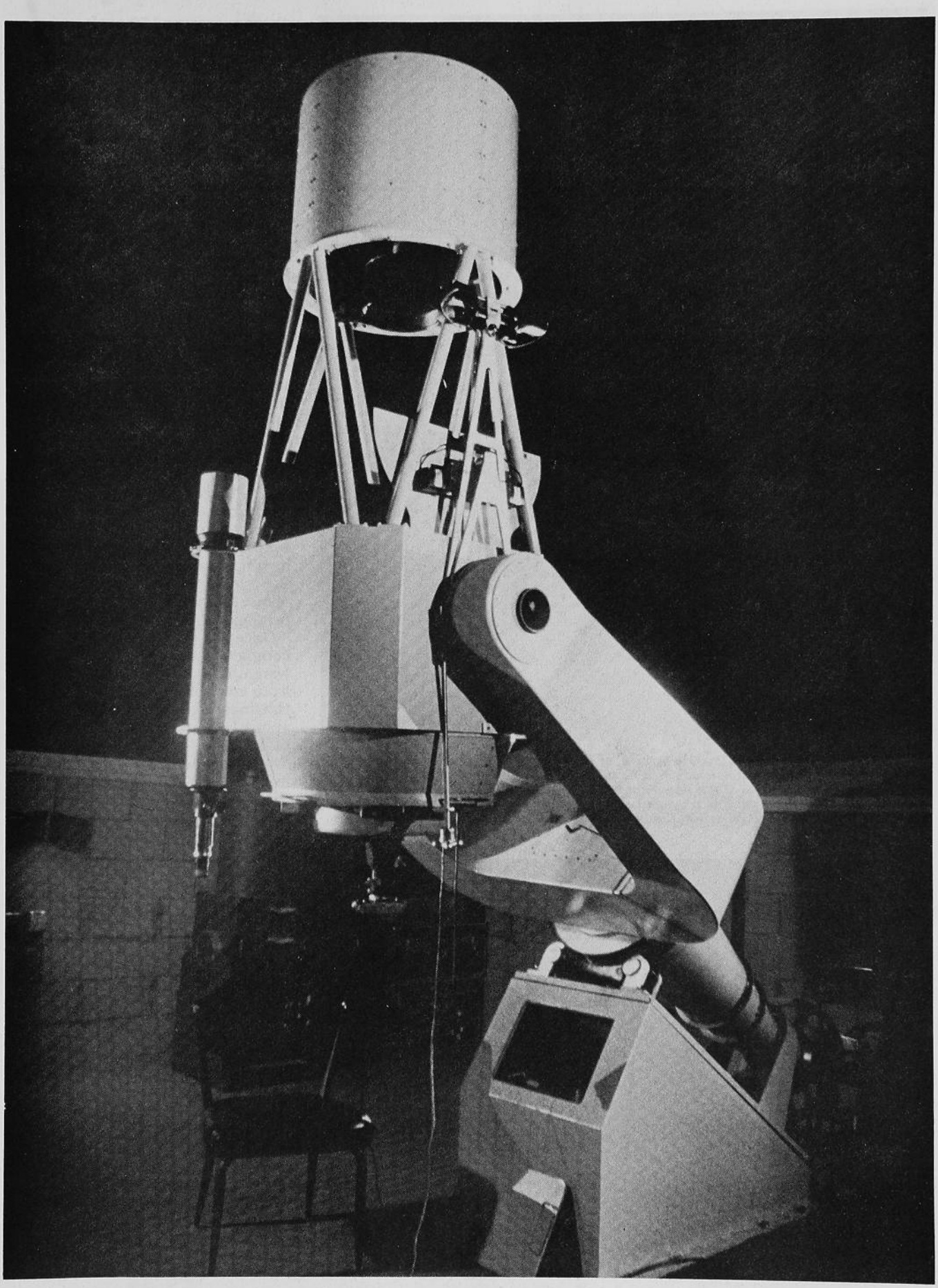
By the time of the formal commencement of the project, the club had grown to a membership of over one hundred. We had incorporated as a non-profit California Corporation.so that we could seek grants from foundations for the construction. In 1973 we received a $10,350 grant for the telescope project from a large local foundation, with the proviso that we would use club resources to build the observatory to house it.

The telescope optics were one of the easiest parts of the project for us. Jerry Brunache, a professional optician with Perkin-Elmer, was given the 22-inch blank which Goff had acquired for the club through a trade. It is C-3, a glass similar to Pyrex. Brunache worked on the optics during lunch hours and after work, acquired the two secondary blanks (one of which is Cervit) for the f/8 and f/16 secondaries, and picked a design from computer formulas at P-E. The telescope is a modified classical Cassegrain that gives a 6-inch-diameter field of good definition for photography with the f/8 secondary. Shortly after the contract was let, the optics were finished and crated until the mechanical end could be completed.

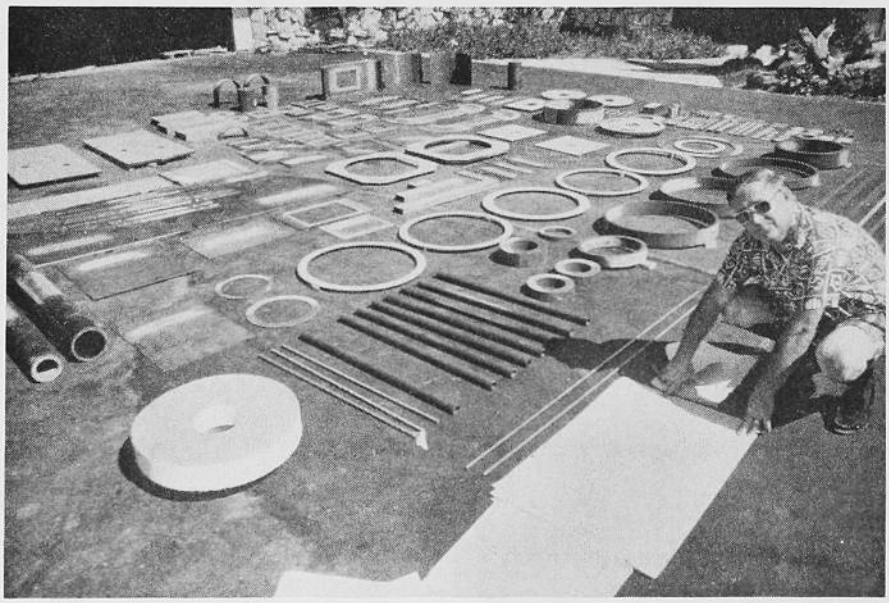
Our club was fortunate to have mechanical engineer and bearing specialist William Kuhn to design and build the telescope. Of course neither he nor the club knew when we started that it would take nine years to construct the instrument, since we had no experience building such a complex item. Bill had built several telescopes, notably a fine 6-inch refractor in a comfortable observatory in his backyard, as well as an aluminum power cruiser boat, so he had quite a bit of practical experience.

First he visited several observatories to note design details. One stop was the U.S. Naval Observatory station at Flagstaff, which houses the astrographic 61-inch reflector. Our telescope shows some design similarities to that instrument. Bill spent over a year doing drawings and engineering the telescope, especially the weight and balance and flexure computations. He opted for a fork mount, a Serrurier truss top end, and a heavy bottom end to keep the fork short. The project grew amazingly! In the end

The William Kuhn Telescope of the Orange County Astronomers. The 22-inch Cassegrain may be used at f/8 or f/16; it is located on the OCA's 20-acre site. All photographs by John Sanford.



Above: William Kuhn in 1973 with a model of the OCA 22-inch Cassegrain reflector, prior to the beginning of construction. Below: Kuhn, with a sheaf of engineering drawings, squats in front of the flame-cut steel components of the 22-inch telescope. The "mirror" (left foreground) is a cement casting with the same weight as the real primary mirror. It was used to test the balance of the telescope.



there were over 150 scale blueprints showing each detail of the major subassemblies--the wedge, the R.A. shaft, the fork, the mirror "tub" and the cell within it, the center box with declination axes, and the truss and secondary supports. The mirror cell and supports were the most complex parts. It has an eighteen-point mirror support system similar to professional instruments; we did not want the ninety-six pound primary mirror being pinched or flexing in its cell.

The materials were chosen to help realize the design philosophy and to allow easy assembly. Steel plate was used for the mirror tub and center box, but the upper end was made of aluminum. This "heavy-bottom, light-top" approach allowed a somewhat shorter fork since the center of gravity is near the primary mirror.

We designed with the user in mind. There is, for example, ample room for auxiliary instrumentation to pass through the fork. The eyepiece is set at a comfortable height for a person sitting below the telescope. The focal point lies about 12 inches behind the primary mirror's rear surface.

Once the drawings were completed, the major components were ordered. These were flame-cut from steel plate of varying thicknesses, to an accuracy of about 1/10 of an inch, so that many of the plates could be welded directly without the need of machining. Ducommon Metals did the cutting. Most of the joints in the wedge and mirror box were welded by John Connelly and then ground smooth by hand. Bill Kuhn moved the pieces from welding shop to machine shop and eventually to paint shop on skids, in a venerable van, usually without help. The heaviest piece, the center box, weighed in at 348 pounds. The complete instrument totals about 3,000 pounds.

By 1978 the telescope was ready for test assembly. It was erected in Kuhn's driveway, using an auto engine hoist, and we installed a dummy mirror made of cement in it. Although the major pieces fit together well, much work still remained. We had to finish machining the mirror cell and the secondary support assemblies, and build the drives.

Until last summer, the right ascension drive consisted of a 1/8-horsepower AC motor reduced by a

commercial gearbox, which drove a pulley around which ran a one-inch-wide multiple-grooved v-belt. This is tensioned around a 21-inch diameter drive disk attached to the R.A. shaft. The diameter of the drive disk was calculated to give sidereal rate when the motor ran on 60 Hz AC power. Larry Muche and Don Anderson made a high quality variable-frequency quartz-crystal power supply to control the motor.

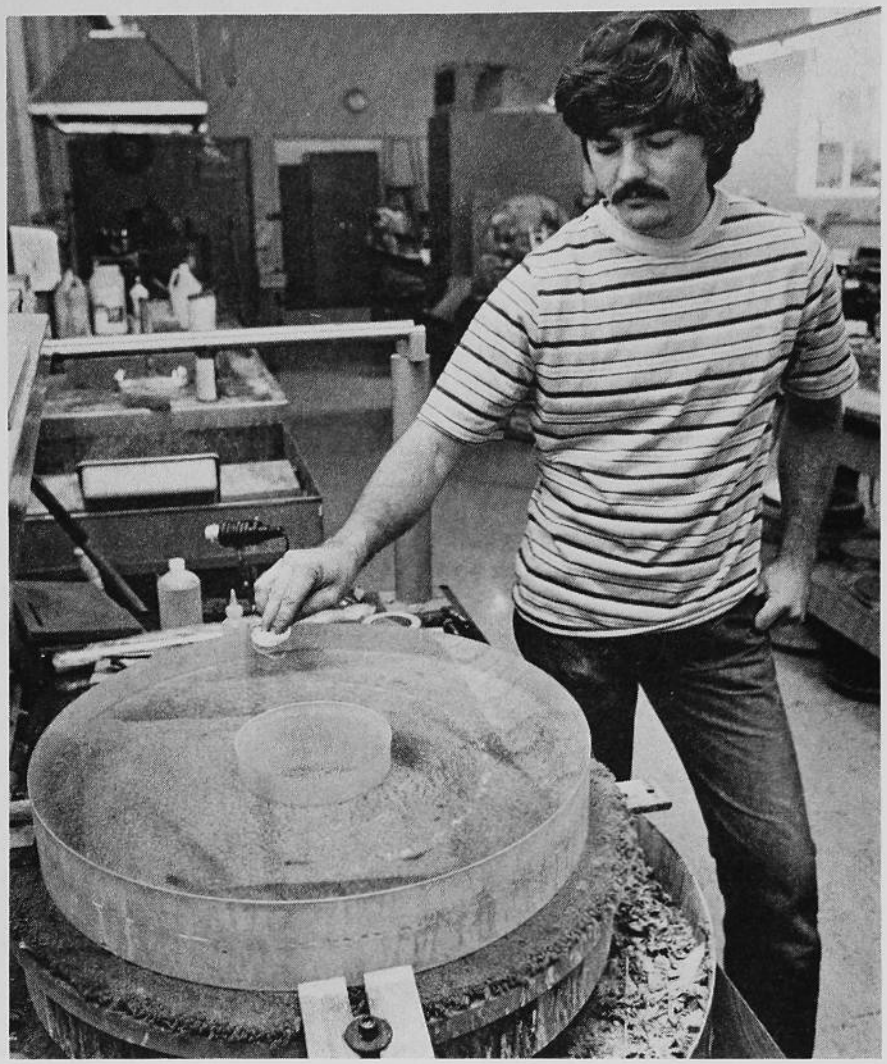
This drive was successful insofar as an object would remain in the field of a 32mm ocular (176x) for several hours. The only problem we encountered was a small amount of backlash, which we attributed to slack in the commercial gearbox 's worm gear. A new drive was installed in the summer of 1987, consisting of a stepper-motor-driven 18-inch worm gear system. This will allow computer positioning of the telescope.

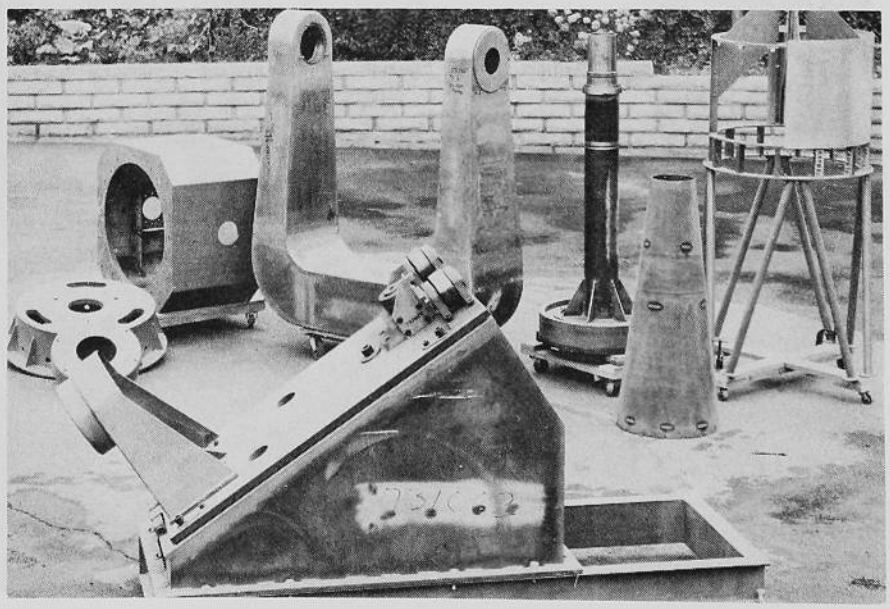
Declination slow motion is provided by two tangent arms that extend from the western fork arm up the tube. The shorter arm provides slewing, and the longer one provides a guiding rate of one arcseconds per second of time for photography. A 4-inch f/10 refractor finder/guider allows precise centering needed for acquisition of objects when a television or other sensor is on the main scope.

As the process of assembling the main telescope went on, the club began to look for a suitable site for the observatory. Initially we concentrated on a saddle in the Santa Ana Mountains at a height of 4,489', but the National Forest Service was difficult to deal with and would not decide whether we could have a lease or not. This site suffered from a poor access road, and the growth of light pollution from Orange County and the nearness of the city of Lake Elsinore concerned us (and our fears have since proven justified).

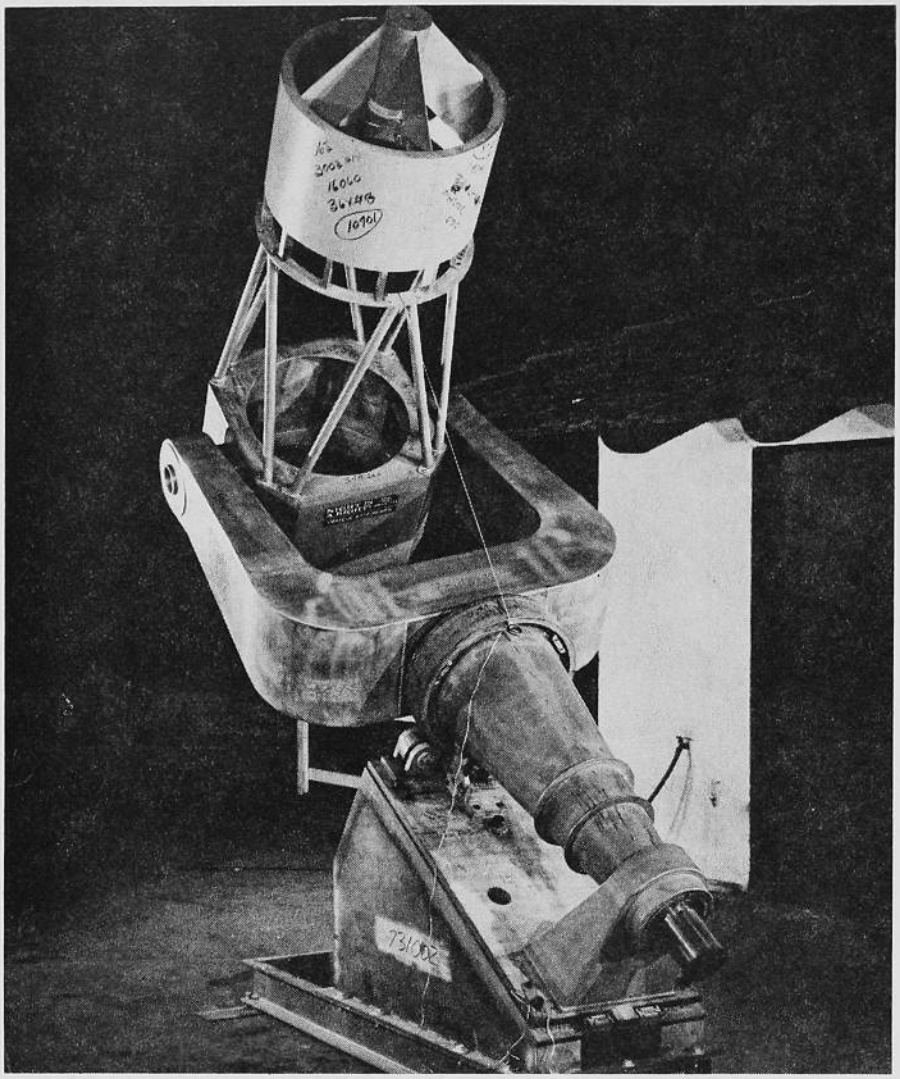
We thought about another site lower in the same area. This had served as a star party site for a couple of years, but we felt that it was too small and too exposed to vandalism, and it was also right above the city of Lake Elsinore.

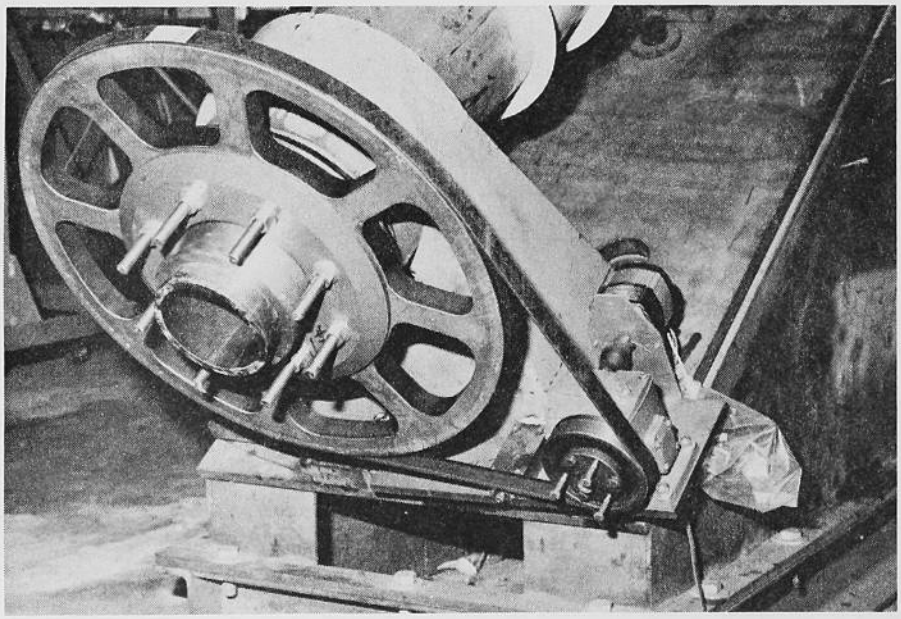
With a 70-mile radius constraint, the club investigated and finally, in 1978, bought a 2.5-acre site in El Cajon Pass, below the village of Wrightwood. This site seemed to have good sky, but a season of experience showed that it suffered from smog blowing around the Mt.





Above: Optician Jerry Brunache with the 22-inch primary mirror. The mirror was completed one week after the signing of the contract to make it. Below: By 1978 all of the major components of the mount had been completed. The tube and mount components are in the background; the mirror cell is at left. Note that the upper r.a. bearings are already installed on the wedge. Mount is bolted to a concrete pier.





Above: The telescope in 1978, assembled for balance and fit checks. Pieces are labeled with numbers corresponding to their numbers on the blueprints. Below: The original r.a. drive mechanism had a 21-inch-diameter drive disk. It was driven by a grooved metal/rubber transmission belt pulled tight over a small pulley turned by a commercial reduction gearbox and a small AC motor.

Baldy massif to the southwest. Furthermore, when there was smog in the atmosphere, the south was fairly bright. We felt increasingly dubious about the site's suitability. When our membership began to grow faster than it had over the previous few years, we realized that it could not park everyone at a star party easily. (Membership reached 200 in 1978 and passed 300 a couple of years later. We are presently over 500 since the Halley spurt!) Even with some leveling, the site was too small.

In 1978 Jack Child succeeded me as president and immediately began to look for a better site -- this time *without* a 70-mile radius restriction. Our 20-acre Anza site, acquired in 1979, is the result of his search. It is located about six miles southeast of Anza and six miles northeast of Aguanga, in rolling desert terrain, at an altitude of 4,360 feet. We decided that this altitude was optimal, since it affords good seeing right at the top of the major inversion layer, yet is low enough to avoid severe winter weather. We have several cold months when the temperature might reach the low twenties Fahrenheit, but have little or no snow (a 4-inch snowfall last winter was unusual, and melted within 48 hours). The summers are hot, with 100+ degree days, often several in row, from June through September. However, the heat is a dry desert type, so it isn't too distressing unless one tries to work outside in the sun during the day. At night the temperature often drops 40 degrees, so we keep the telescope around 70 Fahrenheit by ventilation or air conditioning, to equalize its optics earlier in the evening.

The observatory was designed by club members, with help from Bill Kuhn. Drawings and specifications were completed in 1982. The design includes a roll-off roof, a heated control room, and shower-toilet room. The pier was poured first. Concrete block construction with the blocks filled, plus several tons of reinforcing steel rod, make the building very strong. Construction took about 18 months of work, with one or two work parties a month (usually Saturday, but sometimes Saturday and Sunday) to complete the block construction.

Members Wayne Kaaz, Jack Child, and Don Lynn were construction chairmen, with

Charlie Oostdyk putting in many extra hours beyond the work parties and transporting a lot of the materials in his van. Harry Miller, president during the construction period, supervised much of the work. About 50 members actually participated in the building phase.

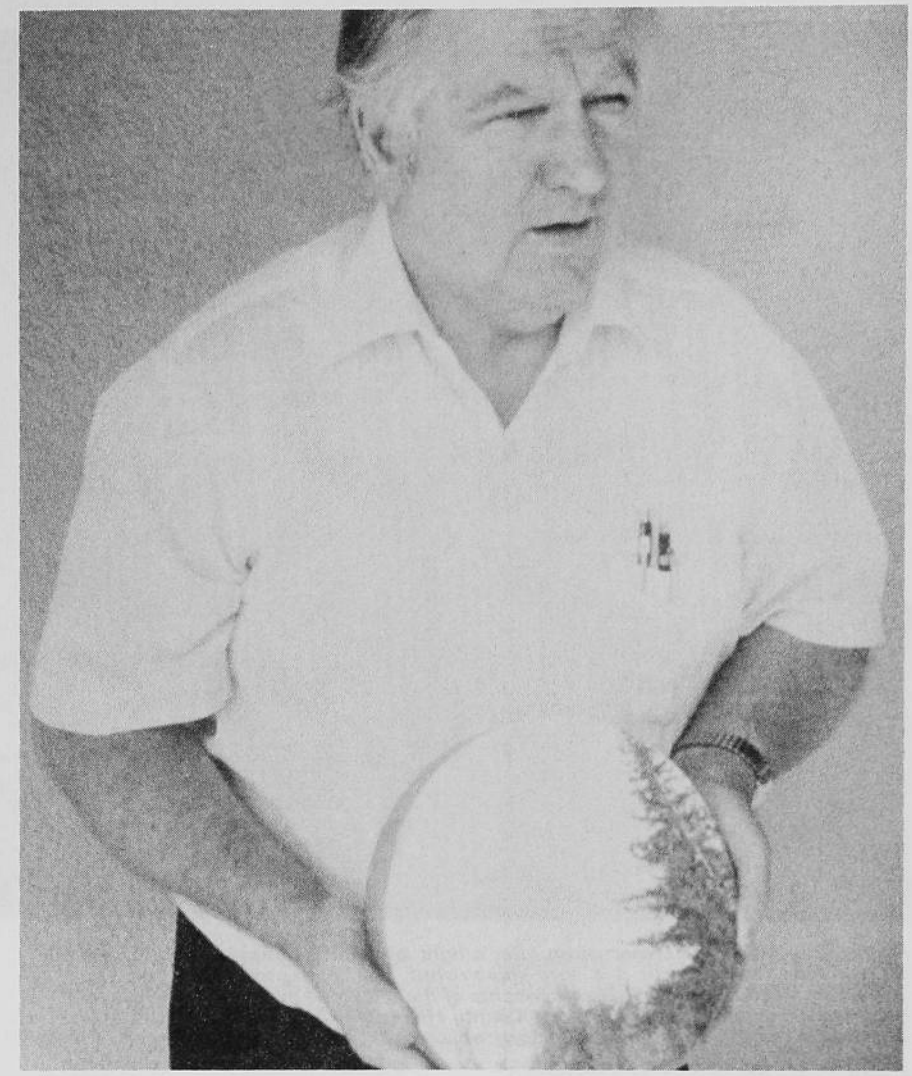
The roof rolls off to the north, allowing very good southern horizon access for the 22-inch and the C-11 auxiliary instrument (we can see Omega Centauri easily, and have glimpses of Canopus between notches in the hills to the south). The floor of the observation room is raised about three feet above grade by a wooden floor so that the telescope looks over the 65-inch high walls. The observing floor--25 feet square--has proven excellent for hosting groups, but remains small enough for efficient two-person operation of the telescope.

Funding for the building was accomplished by the club under its 1981-84 president, Harry Miller, and a committee of Gary Sriro and Bob Hill. No club membership moneys were used for the building construction; all funds were raised by the Observatory Committee through sales, raffles, and donations, primarily by the committee members.

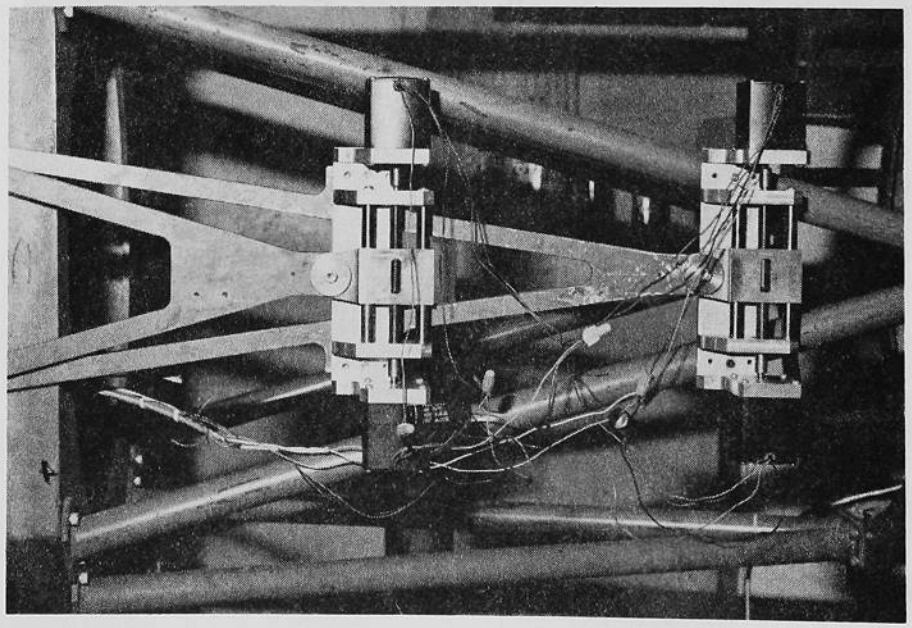
The subdivision in which our site is located is served by telephone and gets electricity from the Anza Valley CoOp. The availability of electricity was a great help during construction, allowing AC power tools to be used (something any group building a remote observatory should consider). We currently buy water to fill our storage tank very reasonably from a neighbor. A major project for 1987 was drilling a well on our property.

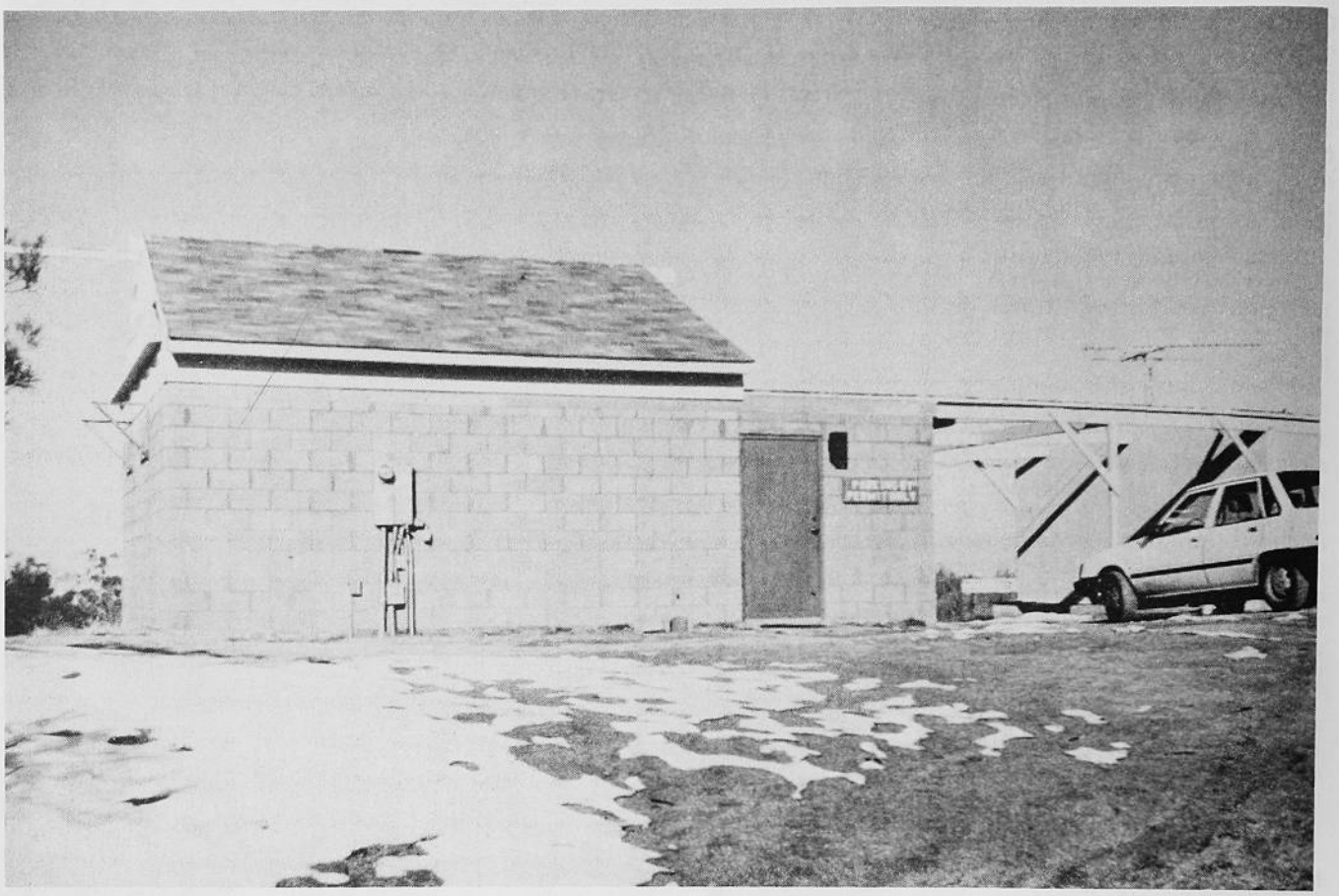
Our sky is quite dark, although we see the light domes of Los Angeles and Orange Counties to the northwest, Palm Springs to the northeast, and Escondido/San Diego to the southwest. Each is only about 15 degrees high, and the important southeast is quite dark.

With growth in the urban areas, however, we are uncertain about our site's usefulness beyond about ten more years, at which time about the only place left for astronomers in southern California will be on mountains, with skies not very dark even there. We may benefit from Palomar Mountain's light pollution control

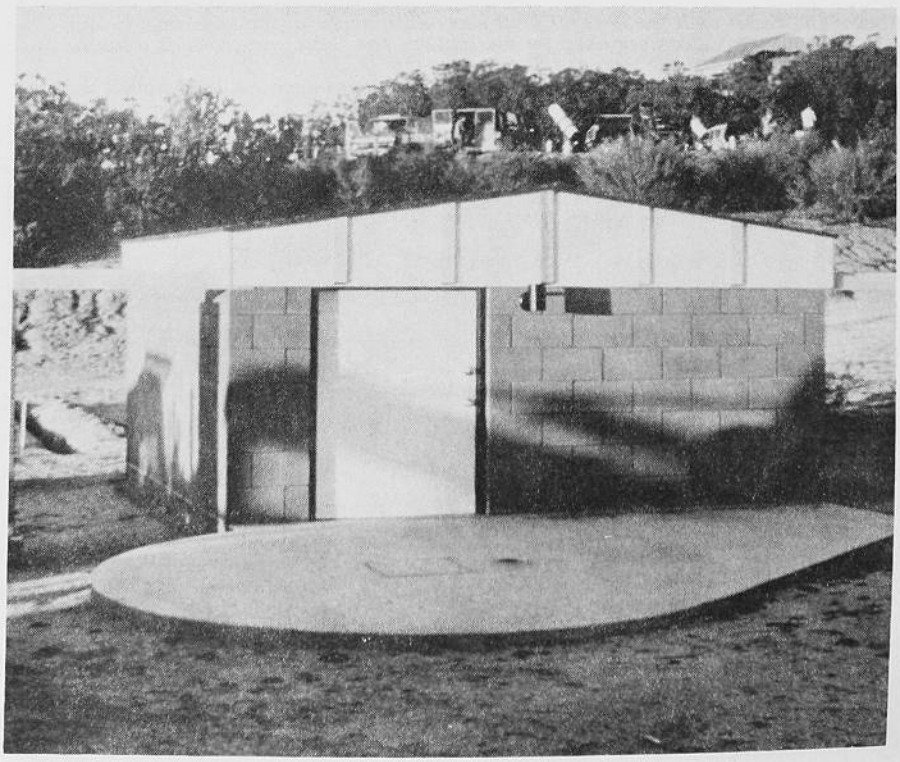


Above: Bill Kuhn with the 9-inch Cervit secondary mirror of the telescope. Below: Two tangent arm drives are used for declination. The short arm provides a fast setting motion, while the long arm is used for fine guiding for photography. To augment this system, 12-inch gear driven by a stepper motor will be installed to allow rapid slewing and computer control of the telescope.





Above: The OCA Anza Observatory after a light snowfall in February 1987. The roll-off roof slides to the north; it is here shown shut. The beam protruding from the gable was used to hoist major components of the telescope into place. The antenna beams video signals to urban Orange County 100 miles away. Below: Carl Blue and Dan Raether owns one of several private observatories on the OCA site.



zone, since we are only about 15 miles northeast of the observatory, but so far, it includes only San Diego County, not Riverside County (our site is near the southern border of Riverside County).

The communities of Palm Desert, Anza, and Rancho California and the nearby canyons are all growing fairly rapidly and pose threats to our dark sky. Currently, however, we can still see M13 in Hercules and Uranus quite easily naked eye, so we have some very good sky, especially when coastal clouds obscure the Los Angeles and San Diego lights!

The Orange County Astronomers have a sub-group called the Electronics Oriented Astronomers (EOA for short), consisting of about 25 members who are interested in photometry, low light video, stepper controls, etc. This group designed and built digital setting circles and a stepper motor control system for the 22-inch telescope. Bert Patterson, Tom Quinn, and Darryl Boom, in particular, have been active in building a low light television system that is producing images showing features down to

One of the leased-pad areas. Three such areas provide a total of 31 pads each served by 110V AC power. A pad costs a member about $200 in developments costs plus $25 per year.

about 16th magnitude, slightly fainter than the visual limit of the 22-inch. The system includes a three-stage intensifier, relay optics, and a cooled CCD video camera.

Eventually, with better cooling and a chip better than the Fairchild television sensor we are currently using, we will eliminate the intensifier. This will improve the dynamic range (limited by the intensifier) and allow observatory CCD performance.

A parallel R&D project is the construction of a low-light video setup by Scott McGurk. This camera features an intensifier physically coupled to the front of a slow-decay phosphor Vidicon tube. The tube is scanned every five seconds rather than at the normal 60-frames-per second rate, thereby reaching fainter magnitudes. We hope to be able to computer-process the deep images captured on tape by this camera in the near future.

A particularly interesting EOA group project is our observatory to city video link. Our site is about 90 road miles from urban Orange County, so we decided to build a link from the observatory to our room at the Boy's Club in Tustin. Amateur radio operators Bob Kneebone and Harry Miller, as well as Bob Hill and others, supplied a transmitter and large Yagi antenna to send video signals back and forth via the amateur television band. A repeater on Modjeska Peak, about 40 miles from the observatory and 20 miles from Tustin, bridges the intervening mountains.

Besides the main telescope, the Anza Observatory site offers OCA members their own observing pads. Since we started using the site in 1980, thirty-one concrete pads with central piers have been emplaced in three areas. These are leased to members (usually the constructor) on a yearly basis. Each is about 10 to 12 feet square and has power. Several have been improved by their "owners," through the addition of block walls, shelves, storage lockers, etc. There is also a large area for drive-in observers with a 12 x 80-foot cement pad oriented east-west; a special area for RVs,;an overflow camping/parking area; and a special area for members to build their own observatories, several of which are under construction. Future plans include a "headquarters" building with a large warming room/lounge, sleeper rooms, and a kitchen, as well as another bathroom.

Access to the observatory can be arranged by any member trained in the operation of the building and telescope. There are twelve nights a year, at our monthly star parties, when the observatory is open for members and guests. Groups and individuals can use the observatory with a telescope operator for a nominal fee. Students or other astronomers with worthwhile projects for a telescope of our size are invited to contact the scheduling committee by calling Charlie Oostdyk at (714) 751-5381, or through the club office at the address below.

John Sanford
2215 Martha Ave.
Orange, CA 92667

The Schalck-Newtonian

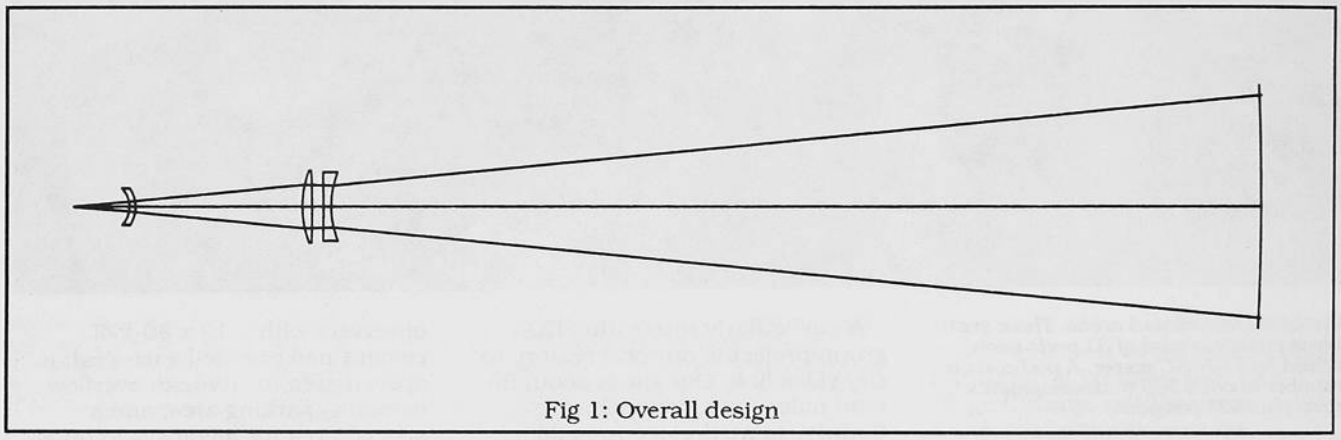


Fig 1: Overall design

It has been over 320 years since Newton described the design of the telescope that is named for him. For most of that time, the design has persisted virtually unchanged. However, since computers have been used in optical design, an array of telescope types based on the Newtonian have come to light: the Jones-Bird (*TM#3*, pg. 14), Ross corrector (see **Lens Design Fundamentals**, by Rudolph Kingslake), and the Schmidt and Baker systems (see **ATM**, Book 2 and 3). Each of these designs has sought to remove the major flaw in the Newtonian, i.e., to remove coma in the off-axis field. But each of them suffers from its own flaws.

The criteria I chose for the Schalck-Newtonian were based on principles espoused in two articles by Harrie Rutten and Martin van Venrooij (see *TM#14*, page 18, and *TM#16*, page 5). The design would have to: 1) be a photo-visual system; 2) employ only spherical surfaces; 3) offer a flat, well-corrected field for 35mm photography; 4) work well for an

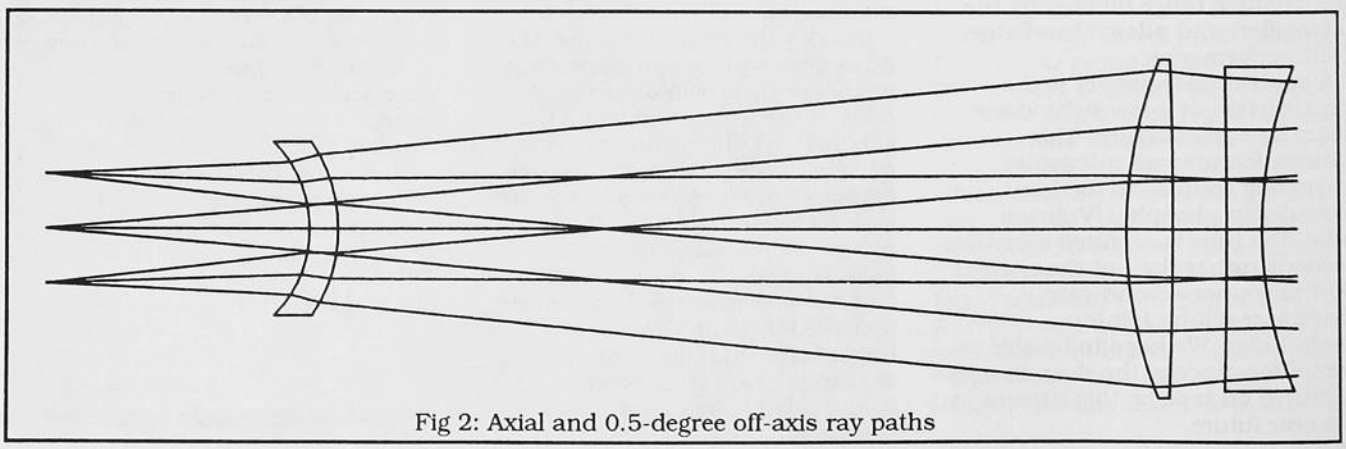


Fig 2: Axial and 0.5-degree off-axis ray paths

Optical Specifications for the Schalck-Newtonian (in millimeters)

*RTG RADIUS
SCHALCKTELII

SRF	RADIUS	THICKNESS	APERTURE	GLASS	NOTE
1	--	1500.000000	145.500000S	AIR	
2	-3000.000000	-1220.000000	158.750000	REFLECT	
3	117.400000	-10.000000	45.000000	BK7	CC
4	-1737.000000	-15.000000	45.000000	AIR	CC
5	-1179.600000	-13.000000	47.000000	BK7	CX
6	128.100000	-220.000000	47.000000	AIR	CX
7	-42.600000	-8.000000	24.000000	F2	CX
8	-33.700000	-73.725728S	24.000000	AIR	CC
9	--	--	15.023970S	AIR	

*GENERAL DATA

EPR	OBY	THO	FMODE	IMAGE	DESIGNER
145.500000	8.72680E+07	1.00000E+10	FOC	9	RES
UNITS	OBX	CVO	AMODE	ASTOP	REV. D4
1.000000	8.72680E+07	--	TRA	1	HP32DHUM1

*PARAXIAL CONSTANTS

EFL	FNB	GIH	PIV	PTZRAD	TMAG
-1721.588795	5.916116	-15.023970	1.269749	-313.567709	-1.72159E-07

*PARAXIAL TRACE

SRF	PY	PU	PI	PYC	PUC	PIC
9	--	0.084515	0.084515	-15.023970	0.029821	0.029821

*SEIDEL ABERRATIONS

SRF	SA3	CM3	AS3	PZ3	DS3	PA3
SM	0.005844	-0.011212	-0.011993	0.030419	-0.171641	0.747965

*FIFTH-ORDER ABERRATIONS

SRF	SA5	CM5	AS5	PZ5	DS5	SA7
SM	-0.009662	0.039964	0.002337	0.002129	-0.023946	-0.002306

*PARAXIAL CHROMATIC ABERRATIONS

SRF	PAC	SAC	PLC	SLC
SM	0.007895	0.005610	0.000662	3.50280E-05

*WAVELENGTHS

WV1	WV2	WV3
0.587560	0.486130	0.656270
WT1	WT2	WT3
1.000000	1.000000	1.000000

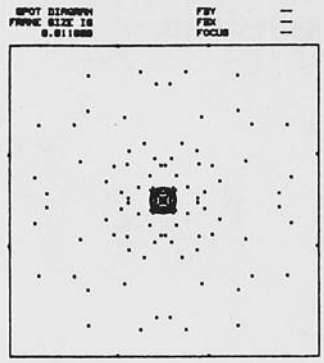


Fig. 3.0: Axial Spot Diagram with 33% obstruction

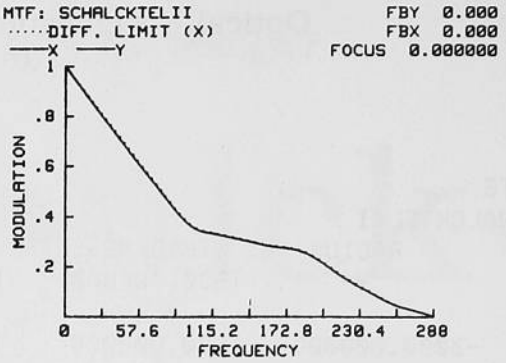


Fig. 3.1: Modulation transfer with 33% obstruction

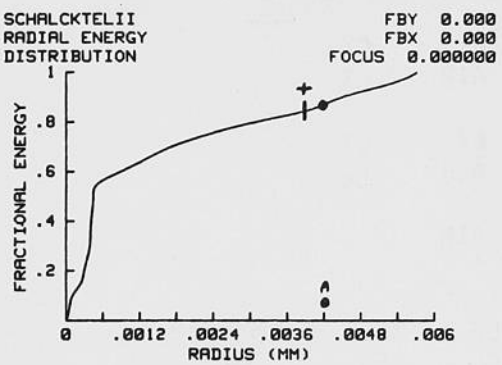


Fig 3.2: Energy Plot, percentage within radius

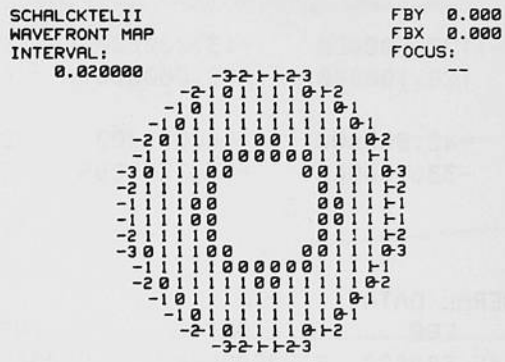


Fig 3.3: Wavefront map with 33% obstruction

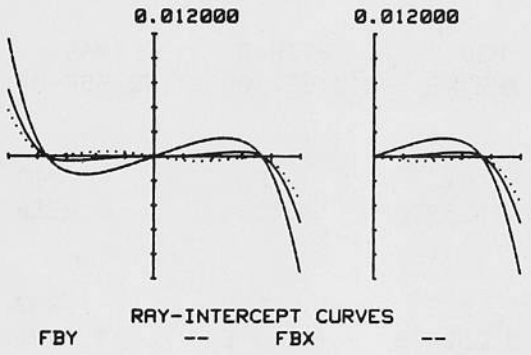


Fig 4.0: Ray Intercept Curves, axial

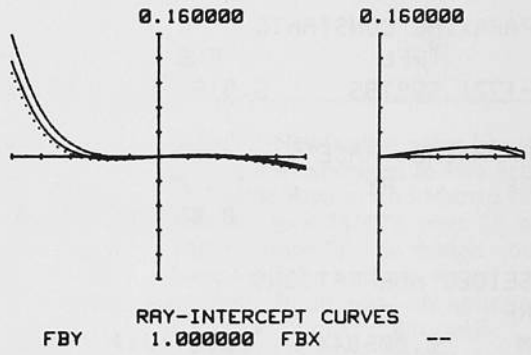


Fig 4.1: Ray Intercept Curves, 0.5-degree off-axis

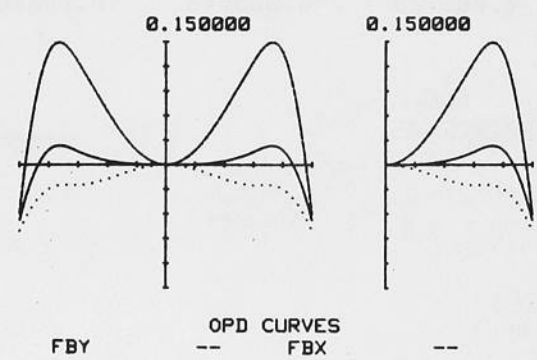


Fig 4.2: Optical Path Difference, axial

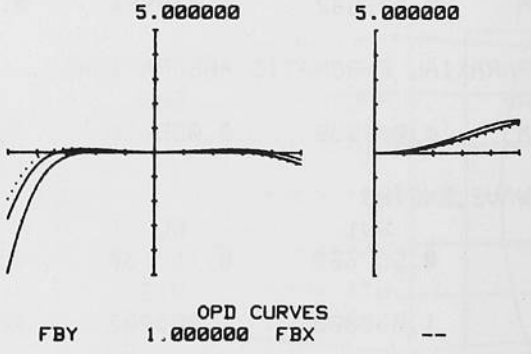


Fig 4.3: Optical Path Difference, 0.5-degree off-axis

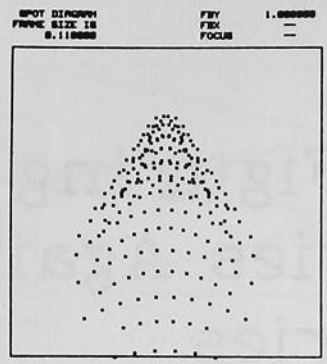


Fig 5.0: Newtonian, 0.5-degree off-axis (.11mm box)

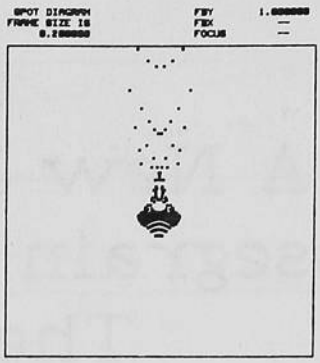


Fig 5.1: Schalck, 0.5-degree off-axis (.2mm box)

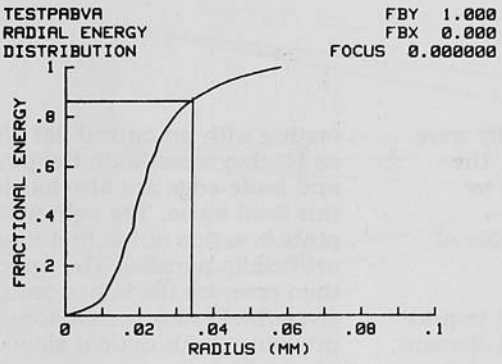


Fig 5.2: Newtonian Energy Plot, 0.5-degree off-axis

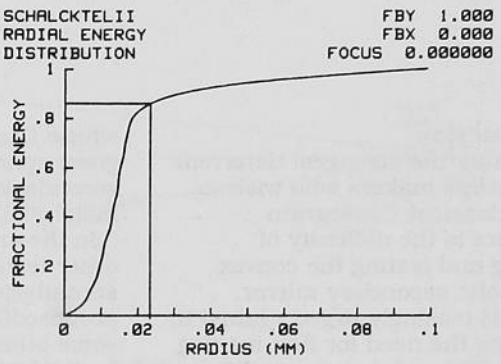


Fig 5.3: Schalck Energy Plot, 0.5-degree off-axis

aperture of at least 300 mm; 5) be free of coma; and 6) show excellent color correction over the field.

I began the design with a spherical mirror 317.5 mm (12.5") in diameter. To correct spherical aberration, I placed corrector lenses in front of the diagonal, and on the tube in front of the focuser. This gave me the ability to seal the optical system. If necessary, an optical window could be placed on the front end of the tube.

The design was entered into the computer by hand. Rough values were used to arrive at the desired focal ratio of f/5. The next step was to review the contribution of each of the surface to the aberration values. Adjustments were made to improve the design before the computer was used for optimization.

Optimization of the design was done using an HP model 320. This computer has a 68020 chip which runs at 17 MHz, and a 68881 FP coprocessor; I was running Super-Oslo software from Sinclair Optics (6780 Palmyra Rd., Fairport, NY 14450). This optimization program allows you to set the values as needed and to improve the design. It uses a damped-least squares method of finding the solutions.

After a few iterations, I checked the design using a real ray trace. The spot diagrams give an idea of what to expect in the performance of the telescope. The optimization continues until the design meets the criteria. It was during this stage, that the second corrector lens was added to improve the design.

In reviewing the spot diagrams and graphs in this article, you can see that the performance is very good. The color error is so small that it is barely visible in the spot diagrams. The ray intercept curves also show good performance.

After looking at all of these graphs, what does one conclude? Well, I achieved my design goals: No aspherics were needed, the images are excellent over a flat field the size of a 35mm film frame, and the system is diffraction-limited for visual use at least two minutes of arc off-axis (Figures 3.0 to 3.3). Furthermore, the color correction error is less than 1 micron (see Figures 4.0 and 4.1). Overall, the images are excellent across the entire field. Based on 25-micron film grain size, 85 percent of the energy falls within a 44-micron circle at 0.5 degree off-axis. For a Newtonian the comparable figure is 70 microns.

The challenge in building this design is making the lenses. Radii 3 and 5 should be held to less than 1 percent. But even if the radii are off a bit, you can still adjust the spacing of the first corrector element for best performance.

If you would like to build one of these systems, contact me. I will give you a more detailed analysis. If you don't want to make the lenses but would like to construct one of these telescopes, I will put you in touch with a local optical shop. They may be willing to make up a few sets of the lenses.

I am now having the optics for a prototype made. By the spring of 1988 I hope to have a working instrument and to have taken some photographs to demonstrate its performance.

Robert Schalck
Optical Research Associate
Allergan-Humphrey Instruments
3081 Teagarden Street
San Leandro, CA 94577

A New Test for Figuring Cassegrain Secondaries Against Their Primaries

Introduction

Probably the strongest deterrent to telescope makers who wish to build classical Cassegrain reflectors is the difficulty of figuring and testing the convex hyperbolic secondary mirror. Porter(1) teasingly urged against it, stressing the need for first making a third mirror element, usually an optical flat. Three or five(2) reflections are needed in order to obtain a null test, and the optical test bed requires precise collimation. Hindle(3) proposed a method in which a perforated spherical mirror substitutes for the primary and flat. This reduces the number of reflections to three and is a null test, but workers still have to fashion the third mirror.

Other Cassegrain-like forms are possible. Kirkham(4) and Dall independently hit upon the optical modification bearing their names, which leaves the secondary spherical while undercorrecting the primary. This, however, produces coma "which becomes 2 to 6 times as large as in a true Cassegrain."(5) Likewise, Pressman and Camichel (as described in Texereau, p. 147), to ease the figuring difficulties of making a large, fast parabolic primary, leave this element spherical, while giving the secondary an oblate spheroid figure. But this design is hampered by coma "4 to 12 times that of the true Cassegrain" (Texereau, p. 147). Nevertheless, this method was independently worked out (with apparent success) some years before by Bernhard Schmidt, whose Cassegrains "usually were given spherical primaries, the secondaries being figured to match."(6)

In the meantime, a number of other tests for hyperbolic secondaries have been proposed(7-14). Nearly all require some other type of optical element, be it a lens or contact test plate, or testing through the glass. Some of these are null tests; others make quantitative zonal readings.

However, I wished to figure the optics of a Cassegrain telescope myself, by limiting the number of reflections to only two. What I present here is a description of a quantitative test that does just that. It works in practice as well as in theory. Along with some unconventional fabrication methods, this test may encourage other amateurs who have been wavering over the difficulties or the extra figuring necessary in the other ways to build compound telescopes.

Principle of the Test

The principle of the test is relatively simple, although a fair amount of custom calculation--basically optical ray tracing the test setup--is necessary for the optical system one wishes to design. First, consider the optical configuration of the primary and secondary mirrors as they will appear in the finished telescope (see Figure 1). The mirrors are positioned so as to reflect incoming parallel light to focus f2 behind the perforation in the primary mirror. In autocollimation testing with an optical flat (known as Ritchey's method), the pinhole and knife-edge are also located at this final focus. The light which the pinhole sends out is first made artificially parallel. The optical flat then reverses the light's path, and gives the system a null appearance providing both optical elements are perfect.

Now imagine what happens if the secondary mirror is separated from its original location and moved along the axis, away from the primary, as shown in Figure 2. Because light from the pinhole now strikes the secondary in a less-divergent cone than before, upon reflection from the primary it will reconverge somewhere far in front of the system. It is here that the knife-edge could be placed and the various zones of the secondary measured quantitatively, much as if one were performing a test at the center of curvature. The readings would then indicate what action should be taken next in figuring the surface.

At this point, an obvious question should be answered: How much farther should the secondary mirror be moved in order to make the test? Unfortunately, there is no single answer. Even if the secondary is moved only a few inches, the reconvergence point may be located several hundred inches away. This makes the test surface too small to see and requires a testing room much too long. Separating the mirror too far, however, causes the reconvergence point to move too near, resulting in a large obstruction of the view by

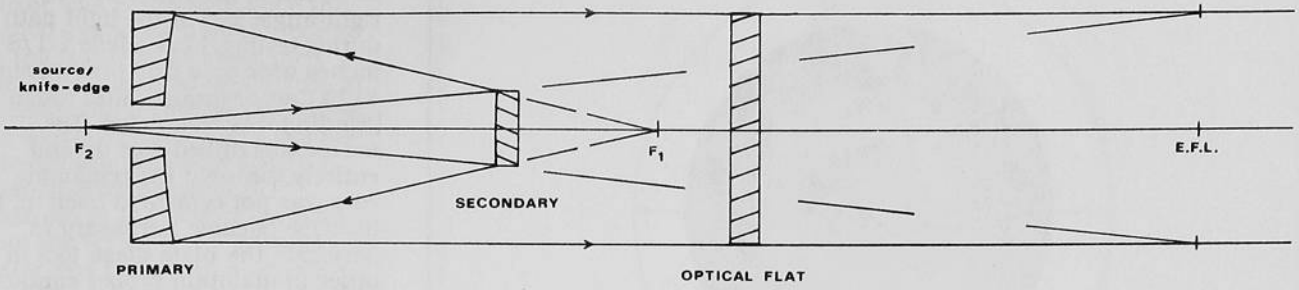


Figure 1: Cassegrain Telescope in Autocollimation Setup

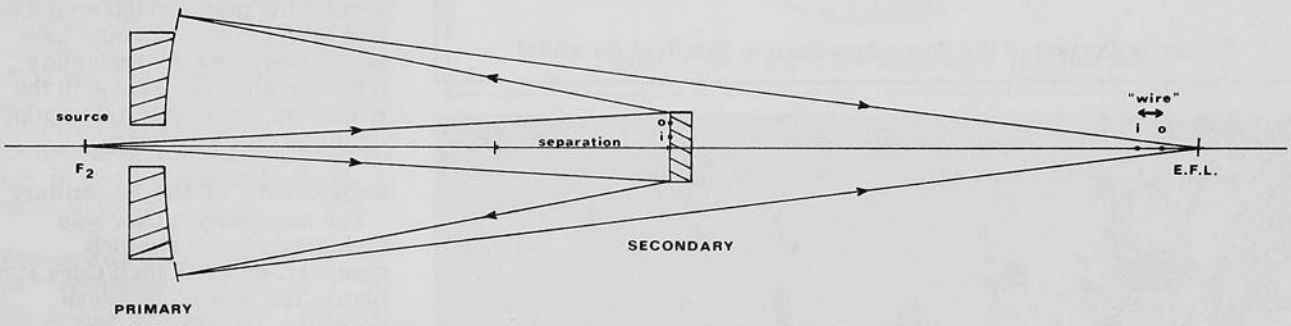


Figure 2: Respaced Cassegrain Telescope Tested at Near Focus

the secondary itself. So how is one to decide? A rule-of-thumb which I chose is to make the separation distance such that a ray of light from the secondary's edge reconverges at the effective focal distance away from the primary's vertex. This seems to be a fair compromise, but one need not adhere strictly to it.

An Example of the Test

For the purpose of evaluating this test, I chose an unconventional design of the finished optics. A parabolic primary must be especially well figured when made in ratios as small as f/4 or f/5. I decided, therefore, that to obtain the most accurate surface possible, a ratio of f/6 would be selected. This has the advantage of relaxing the tolerances on the primary's figure. Likewise, conventional Cassegrain secondary mirrors amplify either 4x or 5x, and are correspondingly difficult to figure. Instead, I chose a 3x secondary, which gives the system an effective ratio of f/18. The primary mirror is six inches in diameter, and the secondary just over two inches across.

After the test conditions were finalized, detailed, two-dimensional ray traces were performed in BASIC on a TI-99/4A microcomputer. The separation of the secondary was calculated by an iterative routine. Light from the source was then bounced off ten-percent increment zones on the secondary, back to the primary and then to the final focus. This gave me a table of the knife-edge measurements that I could expect from the test setup. By changing the optics specified in the optical raytrace, I could see how different surfaces would perform, and trace, for example, a spherical secondary as well as the hyperboloidal secondary I hoped to figure.

The Control

Since the secondary would first be ground and polished spherical before I figured it, I realized that I could determine how this mirror would look when viewed in the test

More importantly, I could discover whether there would be a significant enough difference between the spherical and the corrected secondary mirrors to make the test practical. To answer this question, I ray-traced a spherical mirror of the same radius in ten-percent-zone increments and compared the results.

For the unobstructed conditions, the test looked favorable indeed. But I realized that the center of the secondary could not be tested. Likewise, rays reflected from the edge of the secondary would not hit the primary at all. In effect, my test would show only an annulus on the secondary, between the 37% and 68% zones (Figure 3). I was somewhat discouraged, but decided to go ahead and try it anyway, and the test proved to be useful after all.

I should also note that, between the time the secondary mirror was polished and when it was figured, I had to make a minor revision of the optical design. I discovered in testing that in the fine-grinding of the primary, after I had perforated it, its focal length had dropped to about 34.85 inches. Without any change in the 3x amplification of the secondary, the new effective focal length of the telescope thus had become 104.55 inches.

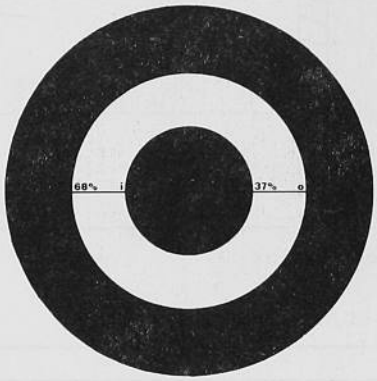
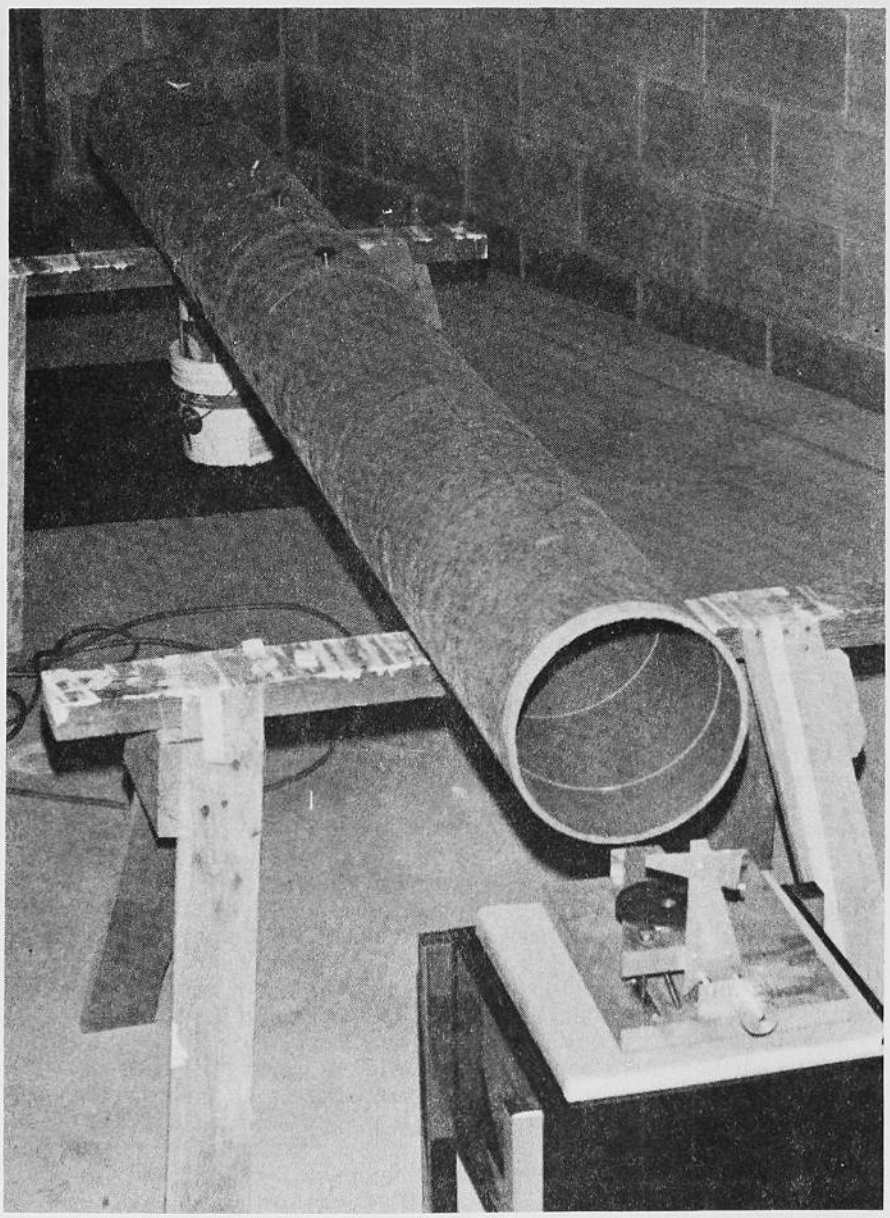


Figure 3: Portion of the Secondary Seen in this Test (in white)



Fabrication of the Primary

I chose to perforate the primary so as not to introduce another right-angle fold in the light path during testing. I cut a hole 1-1/8 inches wide on a drill press, using #120 Carborundum, after rough grinding was completed. The mirror was drilled face up and entirely through; the remaining core was not cemented back in. It likewise became necessary to perforate the plate-glass tool in order to maintain proper contact during the smoothing operations. The mirror was then polished and figured on a pitch lap whose center was also removed. I encountered no difficulties with a turned edge around the hole, though even if one had been present, it would have been covered by the secondary mirror. A smooth figure with the necessary correction was readily obtained on the primary.

Fabrication of the Secondary

The secondary mirror was fashioned from a six-inch diameter, one-half inch thick Pyrex blank. The desired radius of curvature, 31.5 inches, was rough-ground into the blank by hand with #80 Carbo in 12.5 hours, using a full-thickness concave tool on top. The sagitta of the tool was almost exactly equal to the diameter of a 9/64-inch drill bit, so the radius of curvature was checked using it and a straightedge only. Several more hours of grinding by alternating the disks brought the curves back to spherical, as determined by the pencil test.

The secondary blank was then partially perforated face up on the drill press, with a 2-1/4-inch o.d. hole saw. I stopped cutting about one-eighth of an inch from the blank's back side. The entire disk was then treated to conventional fine grinding and polishing techniques, with no unusual difficulties.

After the convex surface had been polished entirely, I coated the glass with two layers of enamel paint and completed the remainder of the coring operation. I thus had a convex mirror 2-1/8 inches in diameter with an approximately spherical figure ready for figuring and testing.

Figure 4: Test set-up in the author's basement. Optics are supported in 8-inch Sonotube later used as the tube of the finished telescope. The tube provides support and stops air currents.

Test Procedures

All testing of the secondary mirror was performed while the optical elements were supported on the inside of an eight-inch diameter Sonotube (see Figure 4). In assembling this configuration, the secondary's distance from the primary was adjusted until the final reconvergence of light occurred at the proper distance from the vertex of the primary. The tester was placed on a separate support beyond the end of the tube. Collimation was accomplished by stringing both ends of the tube with crosshair threads and matching the reflections with their objects. I also found it necessary to install a baffle tube 1.5 inches in diameter to eliminate stray light reflections from the shiny inner walls of the tube. The test apparatus used a simple micrometer screw, reading to 0.001 inch, to perform accurate zonal measurements.

Comparison to a Sphere

My calculations for the hyperbola indicated that I should see a positive knife-edge displacement of 0.173 inches between the innermost and outermost visible zones on the primary. A spherical surface of the same curvature, however, would produce a shift of 0.198 inches. Hence, an secondary mirror would exhibit a greater knife-edge displacement along the axis before it was corrected. The difference between the two, a mere 0.025 inches, proved too small to be detected with the knife-edge. But when a single human hair was substituted for the knife edge--a modified wire test--the difference was fairly easy to see (Figures 5 and 6). However, these measurements were made at the crossover point on the axis, not on the caustic curve.

It also proved useful to compare the actual hyperboloidal surface desired with its corresponding sphere. A graph of the differences between the surfaces vs. radii (Figure 7) showed a maximum deviation of only four millionths of an inch--the amount of glass needed to be polished away from the 70% zone. It also revealed that the uncorrected secondary would introduce an error of twice this amount, or approximately one-third of a wave, into the optical system. Finally, the graph suggested the shape of the "petals"

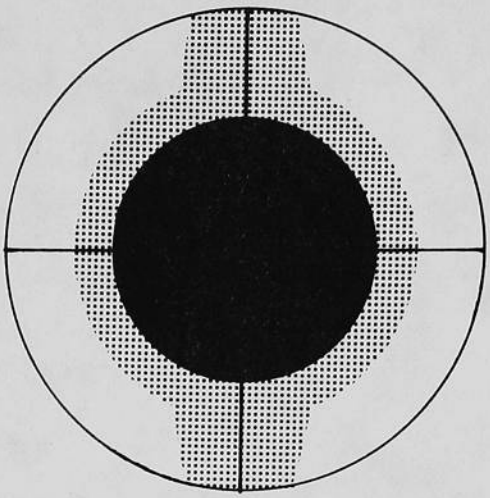


Figure 5: Graying of the Innermost Testable Zone

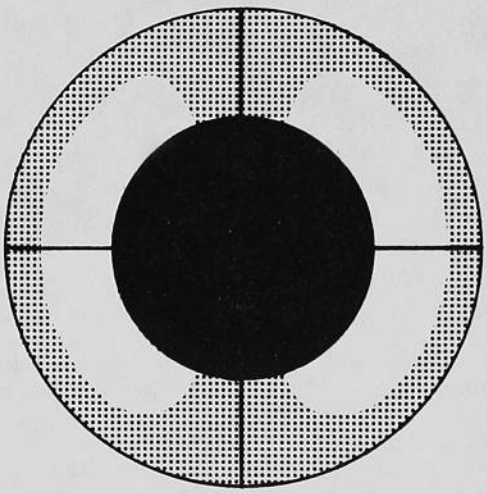


Figure 6: Graying of the Outermost Testable Zone

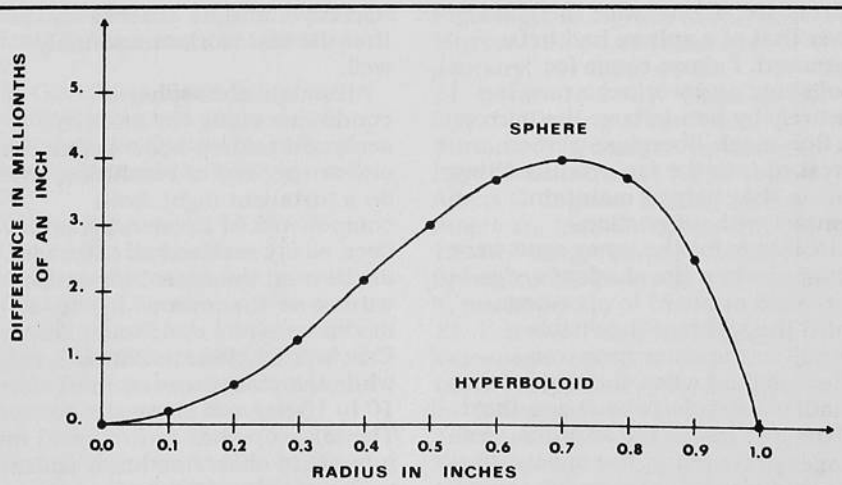


Figure 7: Height Difference between a sphere and a hyperboloid (straight line) as a function of the secondary's radius. The verticle scale is in millionths of an inch.

Figure 8: The 2-1/8-inch secondary mirror and the rose-petal lap used to figure it. This type of lap produces wear on the optical surface proportional to the area of pitch in each zone.

on the rose lap used to do the actual figuring (Figure 8).

Figuring

Upon first examining the secondary mirror with the wire test setup I measured an average displacement along the axis of 0.310 inches. This indicated that the figure was an oblate spheroid, produced from the short, straight polishing strokes on a hard lap. Therefore, about twice the glass over that of a sphere had to be removed. I chose rouge for polishing and worked a rose lap entirely by hand above the mirror. A fine-mesh fiberglass screen pressed into the lap produced tiny facets that helped maintain contact without suction.

Readings for the inner zone were marked when the shadow's edge extended outward to about one-third the width of the visible annulus; the outer zone was likewise read when the edge of the shadow extended about one-third of the way inside the annulus. Both stages occurred at the onset/offset of rapid shadow movement across the middle zone of the annulus.

About a half-dozen 20- to 30-minute figuring spells were needed to reduce the spread of test readings to those I had computed for the hyperboloid. The secondary was then deemed completed.

Evaluation

Final evaluation of the telescope's performance--and indirectly the efficacy of the test--had to await its completion (Figure 9). I am satisfied with the telescope, and its success shows that the test works reasonably well.

Although atmospheric conditions along the eastern seaboard seldom allow better than one arc-second of resolution, even on a turbulent night, both components of Epsilon Lyrae have been easily resolved at 150x with an 18-mm. eyepiece. I have also witnessed shadows of Jupiter's moons cross its disk, and glimpsed Cassini's Division in Saturn's rings while the planet was no more than 10 to 15 degrees above the horizon. The telescope has reawakened my interest in observing lunar features under changing lighting conditions. I'm looking forward to pleasing views of Venus and Mars during 1988.

Furthermore, despite the high f/ratio of the system, deep-sky objects come in loud and clear, showing large angular size with very ample eye relief at medium powers. Even the instrument's baffle tube, which must be supported on four pairs of thin, taut wires, contributes only minor diffraction effects, and does not impair contrast on planetary disks.

I conclude, therefore, that the telescope is working at close to its theoretical performance, and that the testing and figuring methods employed were successful.

Drawbacks of the Test

From measuring only the two intermediate zones on the secondary, it may be argued that the most important part of its surface--namely the edge zone--was never seen (or tested) directly. That is true. I relied strictly on the rose-petal lap to remove glass in

Figure 9: The completed telescope is a 6-inch f/18 Cassegrain. Two-inch galvanized steel pipe fittings serve as the r.a. and declination axes, and for the base tripod. The tube is Sonotube.

proportion to its active area at various radii. In my opinion, the test provided valuable guidance in figuring, and the success of the telescope was not just a fluke.

Conclusions

I have left out the details of the mathematical ray tracing because every optical system chosen must be treated on an individual basis by the designer. I will be glad to assist anyone who inquires about the development of the formulae, and the computer programs written to perform the calculations.

I hope that the successful application of a less cumbersome test for Cassegrain secondaries will encourage other amateur telescope makers to construct Cassegrain telescopes along these lines. I expect that the methods I employed will remain feasible for instruments with secondaries three to four inches in diameter and apertures of ten to twelve inches.

Jordan D. Marche II
116 Village Green Lane
Lancaster, PA 17603

References

1. Russell W. Porter, "How to Make a Cassegrainian (And Why Not To)," **ATM**, Book I, Albert G. Ingalls, Editor, Scientific American, Inc., 1967, pp. 62-65.
2. A second parabolic primary may be substituted for the optical flat, as shown in Earle B. Brown, "Some Principles of the Cassegrainian," *Sky and Telescope*, August, 1946, p. 17(Figure 3).
3. John H Hindle, "A New Test for Cassegrainian and Gregorian Secondary Mirrors," **ATM**, Book I, pp. 225-227 (reprinted from *Monthly Notices of the Royal Astronomical Society*, March, 1931.)
4. Alan R. Kirkham, "The Cassegrainian Telescope with Spherical Secondary Mirror," *Scientific American*, June, 1938, pp. 374-375.
5. Jean Texereau, **How to Make a Telescope**, Second English Edition, Willmann-Bell, Inc., 1984, p. 147.
6. abstracted from N.U. Mayall, translation of biographical sketch of Schmidt by R. Schorr, **ATM**, Book III, Albert G. Ingalls, Editor, Scientific American, Inc., 1953, p. 372.
7. E. Gaviola, "A New Method for Testing Cassegrain Mirrors," *Journal of the Optical Society of America*, November, 1939, pp. 480-483.
8. Wilbur Silvertooth, "A Modification of the Hindle Test for Cassegrain Secondaries", *Journal of the Optical Society of America*, v. 30, 1940, p. 140. See also James W. Gagan, "The Silvertooth Method of Working a Cassegrain Secondary," *Sky and Telescope*, November, 1965, pp. 308-312.
9. Burt A. Norman, "A New Test for Cassegrain Secondaries," *Sky and Telescope*, November, 1957, pp. 38-40.
10. John L. Richter, "A Test for Figuring Cassegrain Secondary Mirrors," *Sky and Telescope*, January, 1970, pp. 49-53.
11. Horace H. Selby, "Notes on the Optical Testing of Aspheric Surfaces," ['Quantitative test of hyperbolic mirrors'] **ATM**, Book II, Albert G. Ingalls, Editor, Scientific American, Inc., 1970, pp. 136-138.
12. J.H. King, "Testing Convex Spherical Surfaces," **A T M**, Book II, pp. 269-271.
13. Texereau, **How to Make a Telescope**, pp. 165-166.
14. Arthur S. Leonard, "A Null Test for Cassegrain Secondaries," **Advanced Telescope Making Techniques, Volume 1 - Optics**, Allan Mackintosh et al., Editors, Willmann-Bell, Inc., 1986, pp. 57-59.

Highlights of the 1987

Stellafane Convention

"Now I never was really all that interested in telescopes. I know that my name has become attached to a telescope, and it had no business to do that. And so far as I know I am the only person who has always complained about calling telescopes by people's names. I'm the one who has always said: Maksutov, Schmaksutov. Cassegrain, Schmassegrain. Schmidt, Schmidt. [Laughter..] And now it's Dobsonian, Schmobsonian."

Thus did John Dobson win over his audience at Stellafane on that hot July night. He had begun with a bit of cosmology, a digression from the heart and soul of Stellafane into the Big Questions that telescope makers often seem to avoid. Now he was talking telescopes, and they had warmed to him.

"It's like re-inventing the cup, you know. The military has been shooting each other dead with these things ever since they had gunpowder. There's nothing odd about it, but apparently nobody ran telescopes this way, and I cannot figure out why.

"But at any rate, I'm not particularly interested in telescopes; I'm interested in information. I'm interested in the problem of making it possible for the people who live in this world to see this universe the way that it really is, and you have to do that through telescopes, and you have to do it at night. You have to help them understand this world, you see.

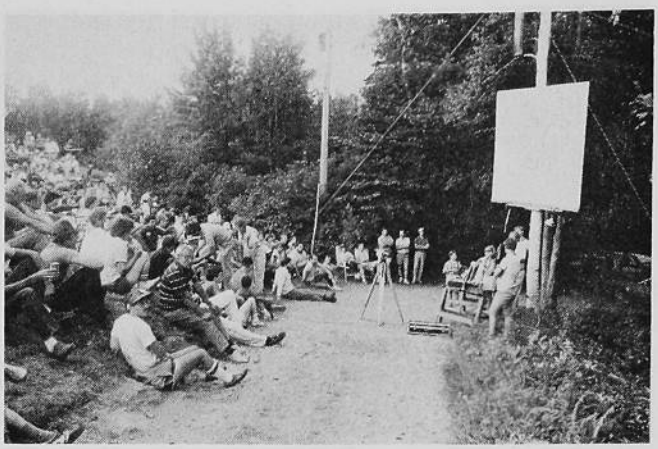
"Now to me it is not so much how big your telescope is, or the lens, or what have you, It's not so much what pretty pictures it takes. It's how many people, in this vast world, less fortunate than you, have had a chance, through your telescope, to see and understand this world. That is the one thing that drives me."

Now they loved him.

John Dobson went on to describe how the Sidewalk Astronomers have toured the United States, putting "80,000 miles of public service" on their 24-incher. He told them why he builds his telescopes so long: "Our 24-incher has a focal length of over thirteen feet; it's an f/6.5. We didn't want to cheat...we set them up for other people to look through....and the reason we use long-focal-length optics is partly because people have to get in with their eyeglasses on without having to focus it, and partly because we have noticed that the rod cells are stupid.

"Just think about it. If there was a barn owl in one of those trees, at this time of night, you'd see only a lump. But you know perfectly well that if you walked right up to it, you'd see his beak, and his eyes, and his feathers, and his feet. This is because the rod cells by which you see the barn owl at night are stupid.

"You can get more information out of the image if you run it at six



powers per inch of aperture than you can at four and a half. You just try it any time and ask a whole bunch of people to come and see where they get more information. I think everybody, at least almost everybody, gets more information at six powers per inch of aperture than at four and a half. I'll admit that it's brighter at four and a half, but there is this terrible difficulty that the rod cells are stupid."

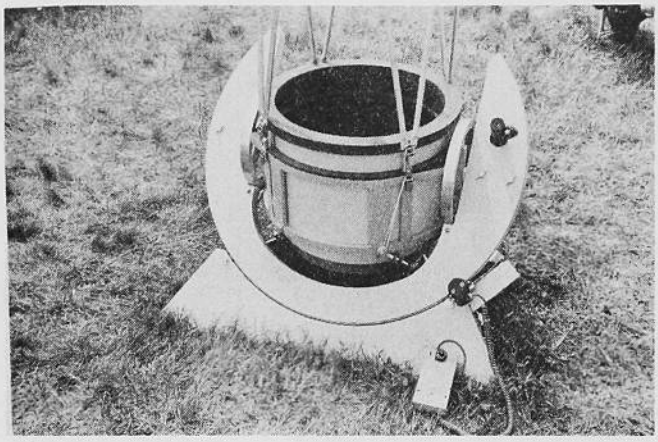
He told how the Sidewalk Astronomers were making new 24-inchers, and would soon have three of them in active use. "I'm very interested," he said, "that all the people who have telescopes should help make it possible for the people who don't have telescopes...to see what the universe really looks like. Porter really got us all started making telescopes. Now it has become a possible thing: if there were a million people with telescopes willing to let a thousand other people look through them, it's possible that everyone who walks on this Earth, with the eyes to see, could see."

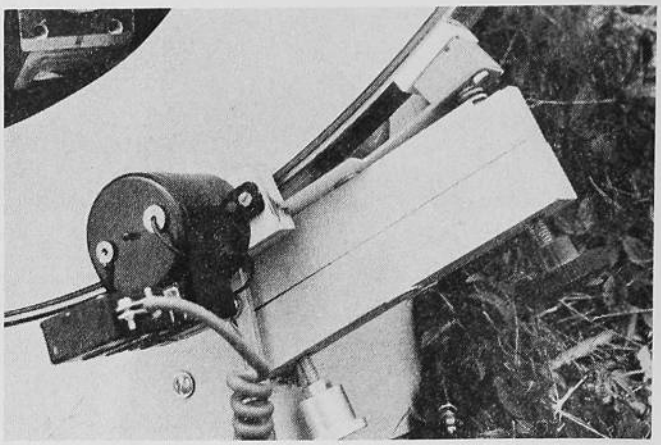
After the talk, John Dobson showed slides and took questions from the crowd on Breezy Hill that night. He spoke of his days in the monastery, of sneaking out to trundle a telescope around, helping the kids in the neighborhood make telescopes.

"Rough grinding is a caveman's job," he told the crowd "Eat well, sleep well, work like hell. Fine grinding is in the suburbs; polishing is in the city; figuring is just like downtown."

"A telescope is too big if you can't move it. If you can get it into the back yard, it's too small."

"Now here's some guy grinning from ear to ear pouring his rough Carborundum on a ten and a half incher. These are all portholes. Years ago I borrowed a bunch of money and went down and bought four tons of porthole glass from American Salvage. That glass is long ago gone. People ask me how many telescopes I've helped people make; it's in the neighborhood of four tons. A lot of that glass was tool glass, of course, but I've bought several tons of glass since then."



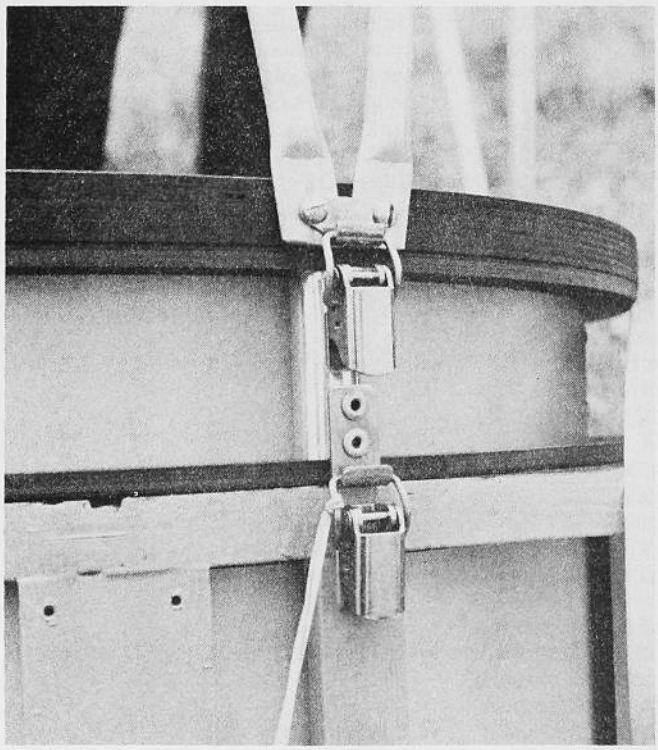


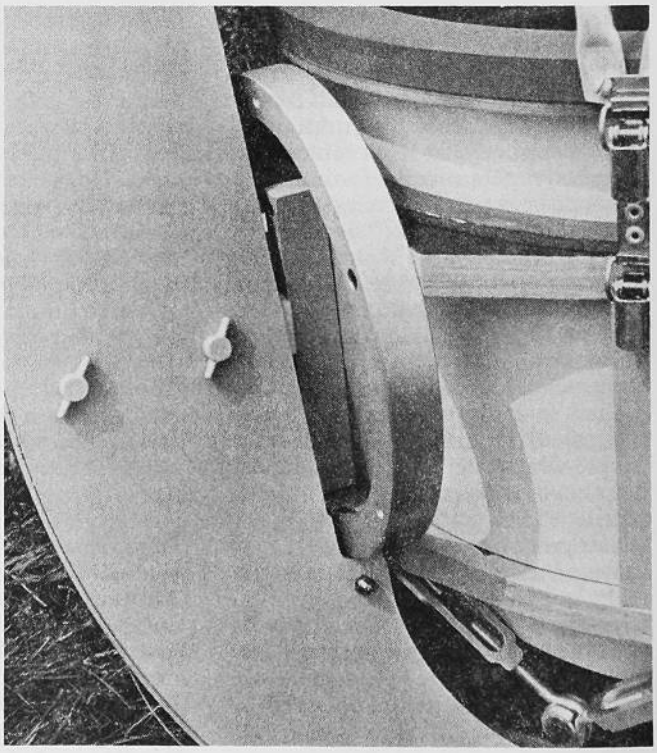
At last: Dobsonian Performance from an Equatorial Mount

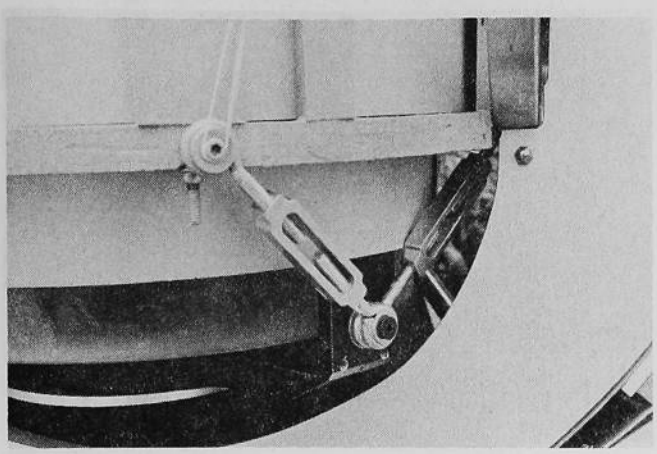
Dozens of telescope makers have tried to duplicate the "feel" of a well balanced Dobsonian in an equatorial, but few have succeeded as well as Gary Walker of Dover, Mass. His 14-inch f/4.4 Newtonian feels like a Dob--thanks to a lightweight Porter split-ring mount. This mount is low to the ground, moves with exquisite smoothness, and weighs only 75 pounds, mirror and all.

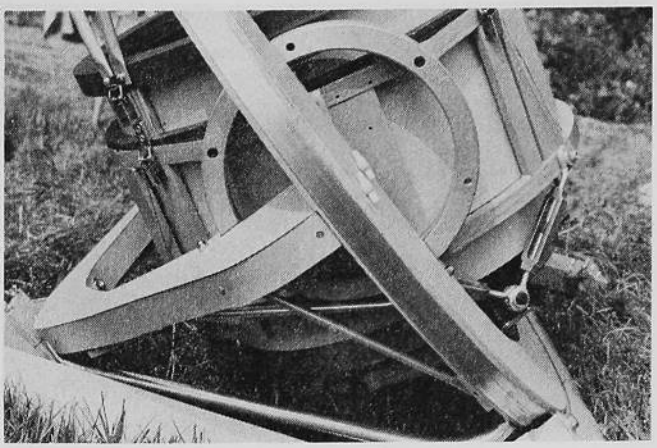
The structure is construction-grade Formica bonded with Elmer's glue to a styrene foam core throughout. Walker cut the large rings with a router, then sanded them true on a Sears sanding table. The split-ring knocks down into the horseshoe and the polar ring; they are assembled with wing-capped bolts. "There are solid wood blocks in strategic places in the structure," notes Walker.

The upper end is held by 1/2" x .049"-wall seamless aluminum rods, and the rods are tied to the upper end by bicycle spokes. A spacer ring between the midsection of the tube and struts allows



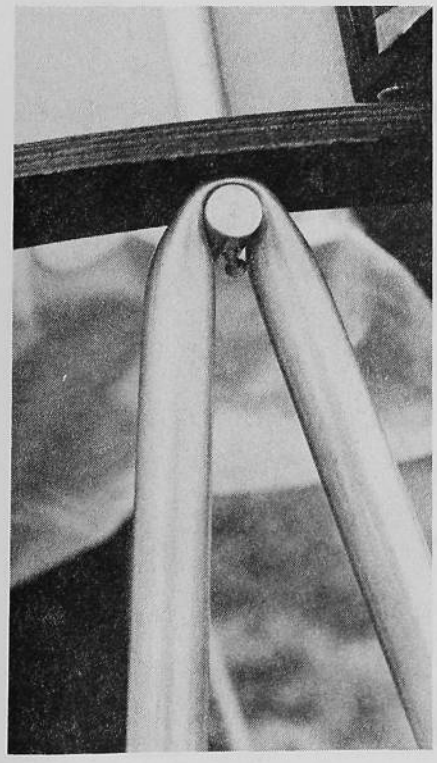


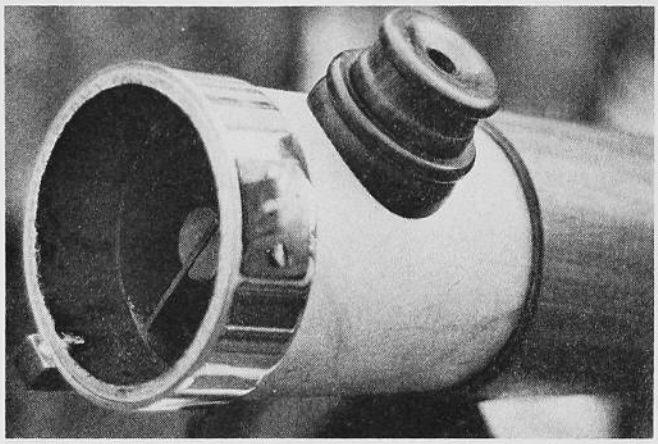


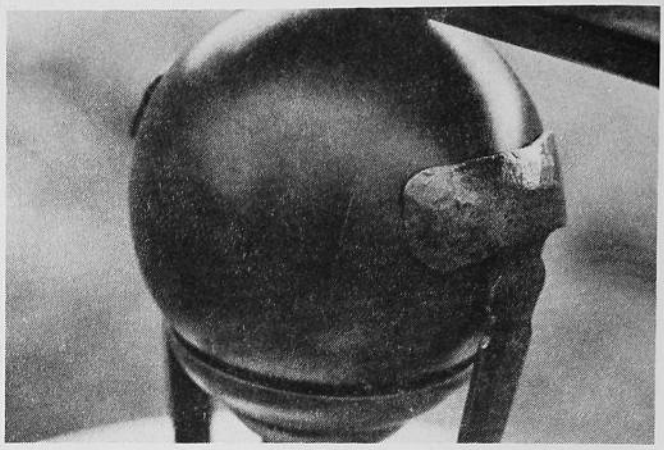


Walker to shorten the tube by 2.6 inches for astrophotography.

The split-ring rides on two hidden ball bearings, and can be driven by a 3/32-inch dowel pin turned by a small DC motor. An adjustable Teflon block adds friction when the drive is disengaged.





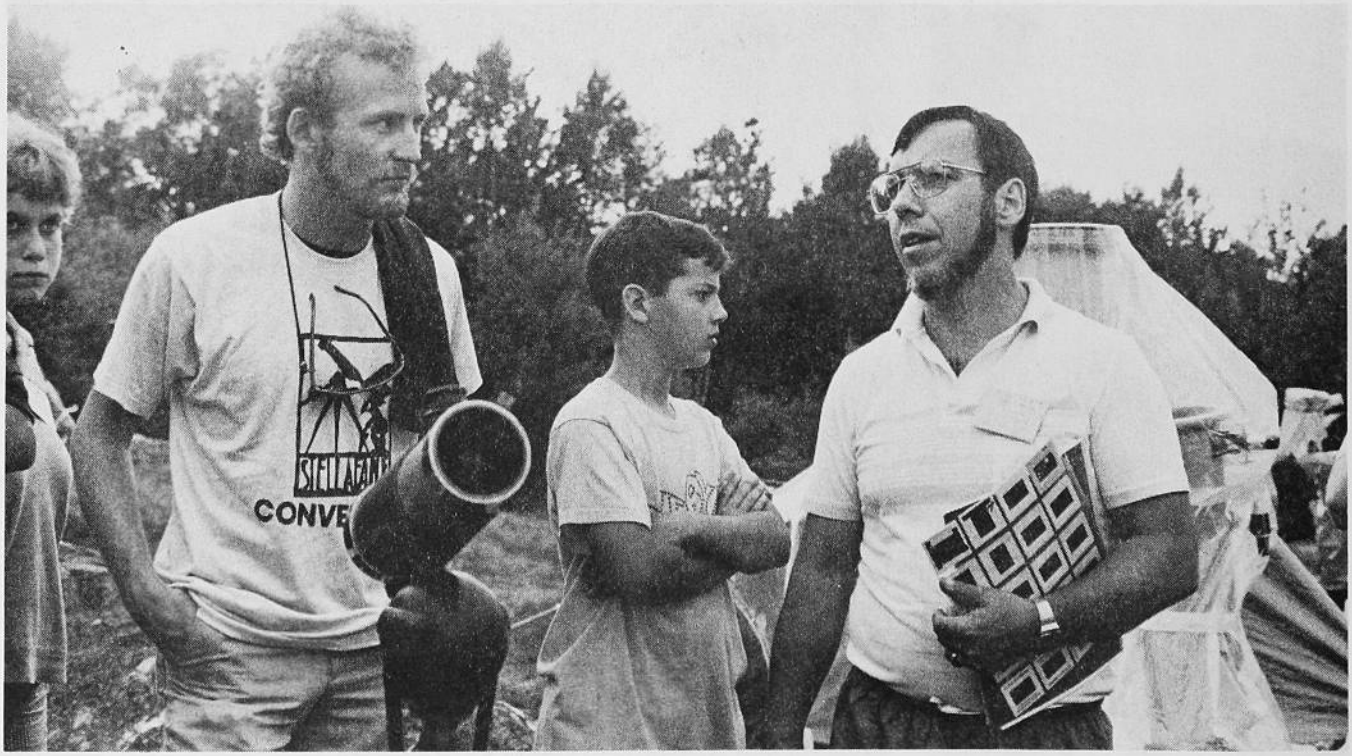


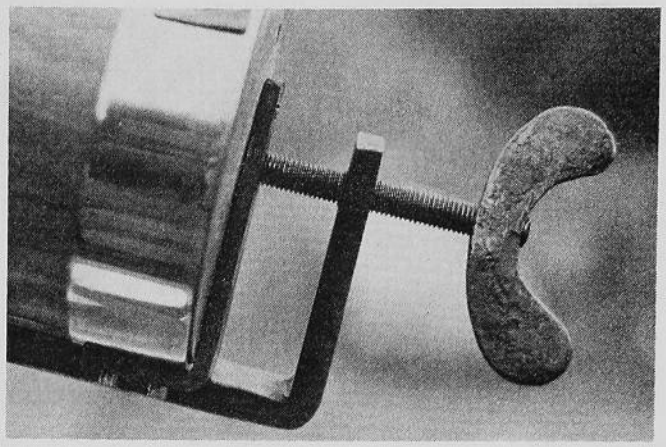
Modeling the Original Newtonian in Wood and Brass

Quebecer Real Manseau displayed his replica of the original Newtonian of 1671. (Newton's original paper on the reflecting telescope was reprinted in Telescope Making #9.) The beautifully-finished instrument is one of two Manseau has made; the other was a gift for his father.

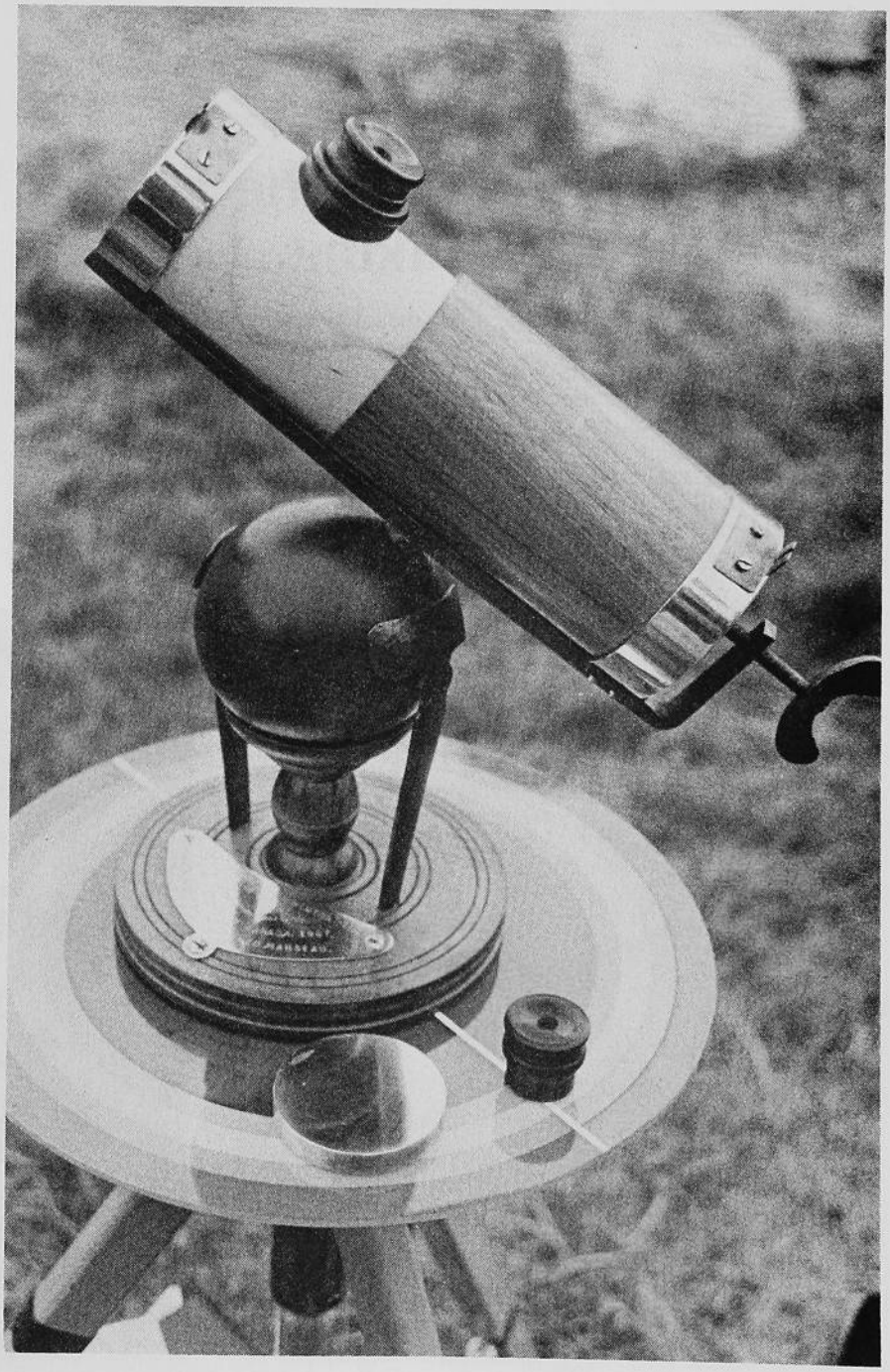
The instrument now has an aluminized glass 2.38-inch f/4.5 mirror in it. Manseau showed a partially polished brass mirror that he hopes to finish and use with the telescope. Newton made his original mirrors from speculum metal. With a turned wooden eyepiece, the telescope gives a magnification of 38x.

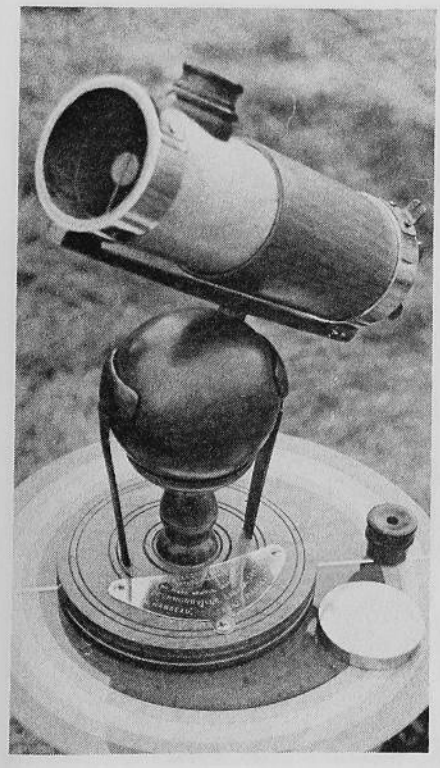
Like Newton's original Newtonian, the telescope moves on a ball held down by wrought-iron springs, and depends on friction to stay put, much like an Astroscan. It is focused by moving the back end of the tube containing the mirror back and forth; the eyepiece is fixed. Both the inner and outer tubes are made of rolled veneer reinforced with brass strips.

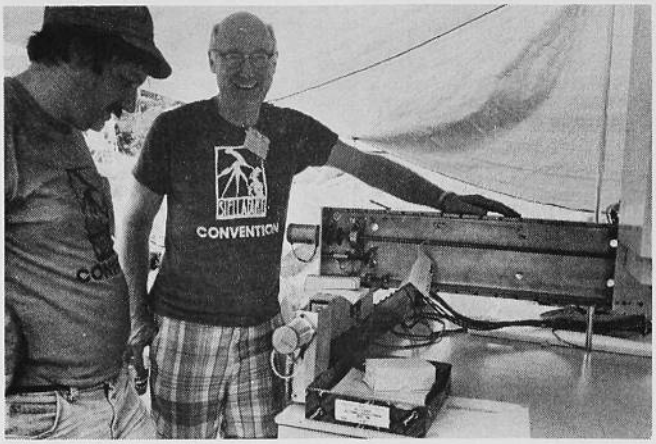


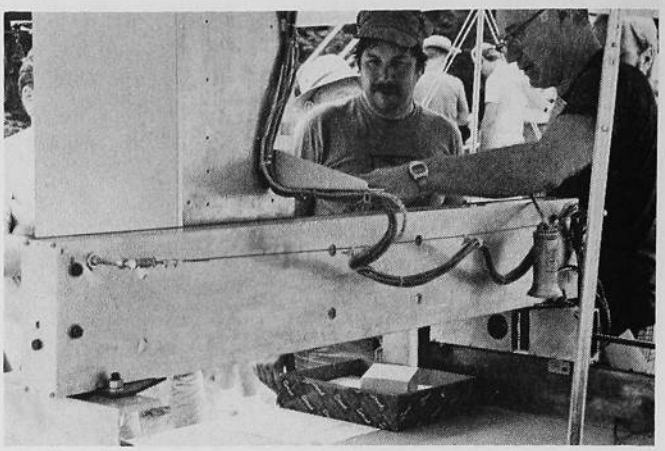


This beautiful little 'scope was a pleasure to discover on the telescope field. It would be great to see more replica telescopes at amateur gatherings.









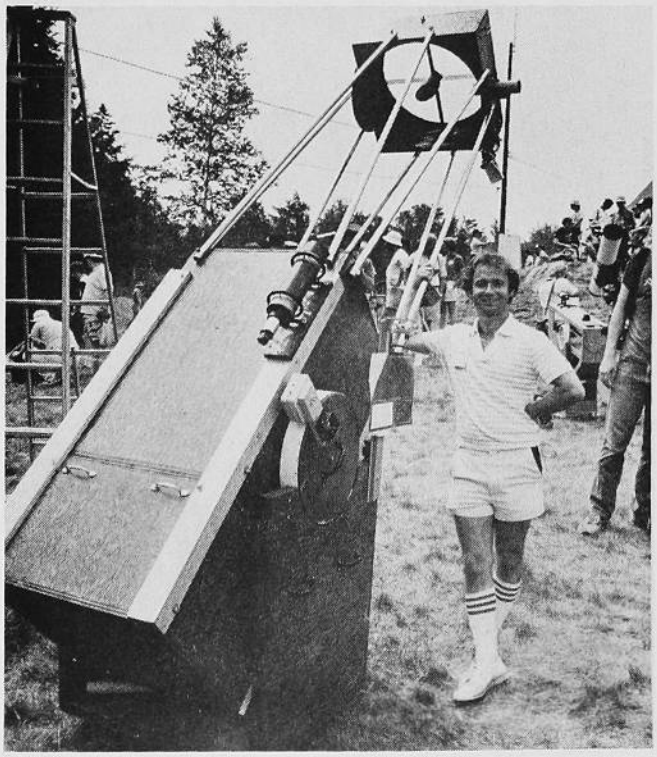
Computers Change the Face of Telescope Making...

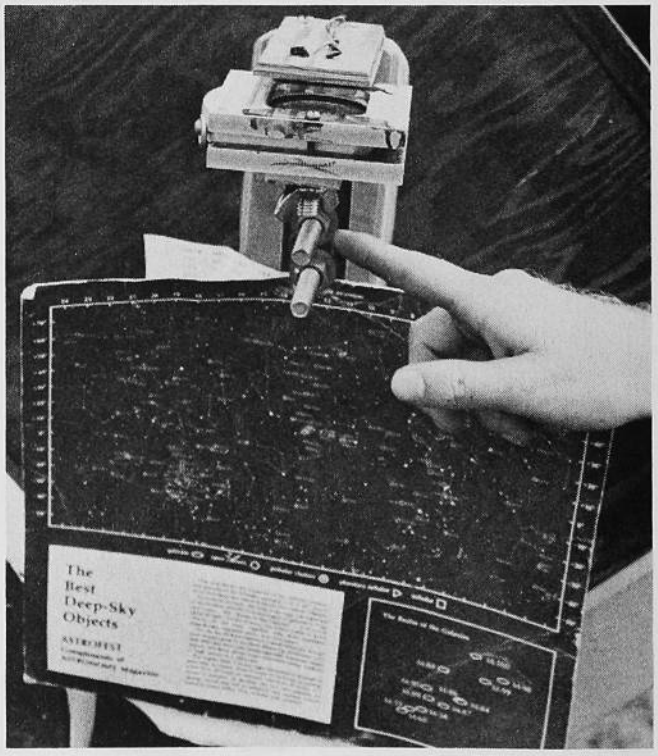
Charles Enz (in photos) and Barry Levin showed their computer-controlled grinding and polishing machine. The machine was constructed "to prove the concept," according to Enz.

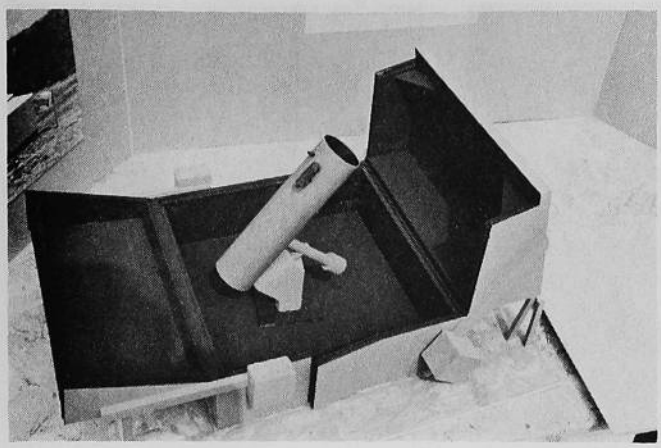
When the software and hardware system is complete, Enz will be able to compute 3-dimensional slope error from caustic test measurements, then integrate these to obtain a surface profile. Output from the testing program generates a file to drive the polisher to correct the surface errors seen in the test.

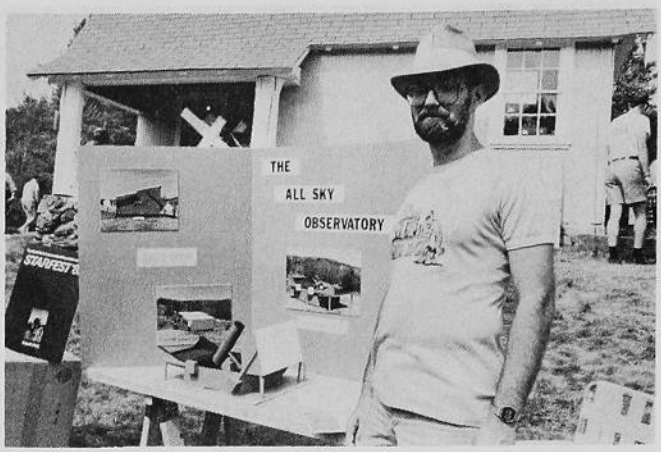
"We'll be able to polish off-axis paraboloids in glass, do toroids, or anything," says Enz.

Simpler but equally influential is Bill Burton and John Kerns' 20-inch f/7 computer-pointed Dobsonian. A Sharp PC 1250A pocket computer finds the altitude and azimuth of the desired object; the observer uses a precision magnetic compass and inclinometer to aim the telescope. "We can easily get twenty objects per hour," says Burton.









...But Simplicity's Still in Fashion

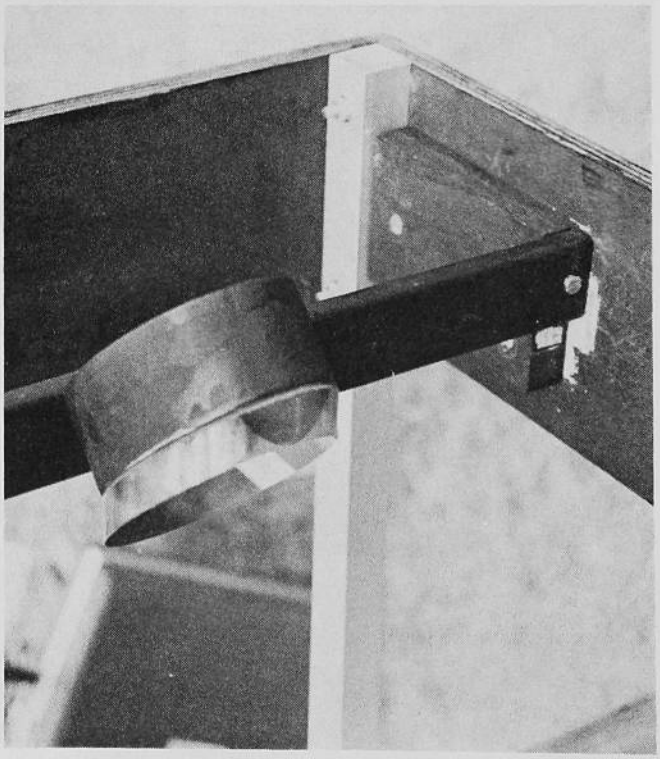
Andreas Gada didn't bring his observatory--but he brought pictures and a model. Measuring 8 feet square, by 5-feet high at one end and 3-feet high at the other, the "flip-top" Oaks Heights Observatory is a model of simplicity and ease of construction.

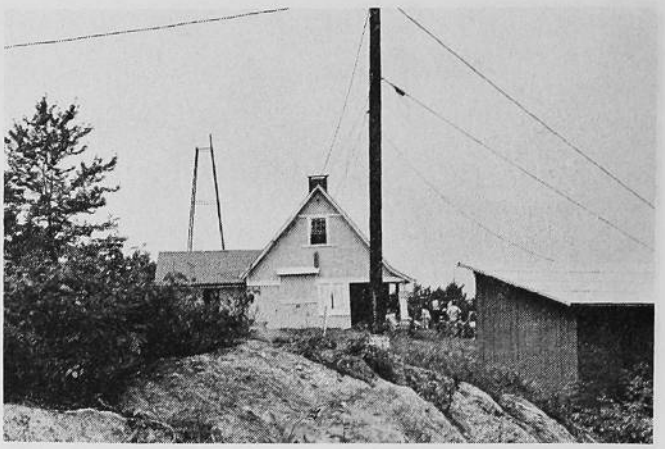
The roof splits in two--one high half and one low half. Concrete weights balance each roof section. Wooden stakes limit the motion of the roof when it is open.

Glenn Burke of West Paterson, NJ, built a 14-inch Dobsonian and kept it very simple. The simple oak plywood box and upper end are joined by 1-inch extruded 1/16-inch-wall, square aluminum stock, which Burke bolts in place.

The mirror cell is held to the back of the tube with suitcase clamps; it is removed for transport. The diagonal design is based on the diagonals in Coulter's Odyssey line of telescopes.

Not only is this telescope simple, but it's compact and operates with exceptional smoothness.



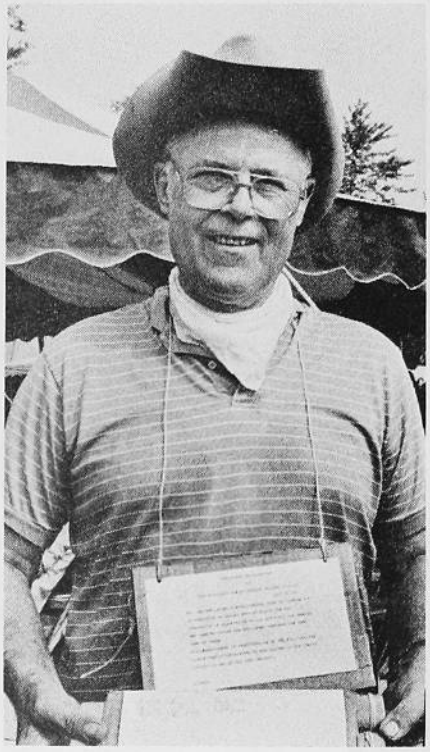


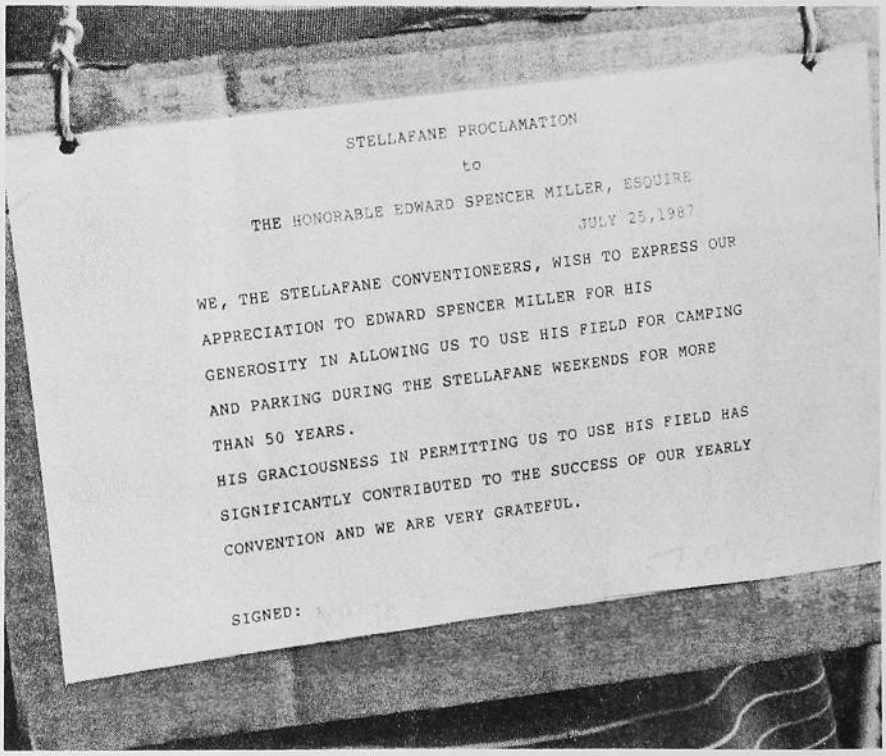
Mixing a New Stellafane with the Old, Familiar One

"Record temperatures and high humidity are predicted for the area with the possibilty of rain or thunderstorms." So said the radio, and by mid-afternoon the temperature was pushing 100 degrees. Yes, it was a typical mid-summer Vermont weekend.

But Stellafane has changed. With the loss of half the camping field to a crop of Christmas trees, the Springfield Telescope Makers has built new camping facilities a little further up the road. I pitched my tent there, on a patch of sloping ground next to a bunch of stumps. But it didn't feel like Stellafane.

That isn't to say that it wasn't Stellafane, and of course something like Stellafane cannot stay unchanged and still remain vital. Nonetheless I must confess to not liking the new bald spot behind the clubhouse--despite seeing Sagittarius and Scorpius in John Vogt's marvelous and monstrous 30-inch reflector. I didn't like camping way out in the boonies, but the walk through the woods almost compensatesd.





STELLAFANE PROCLAMATION

to

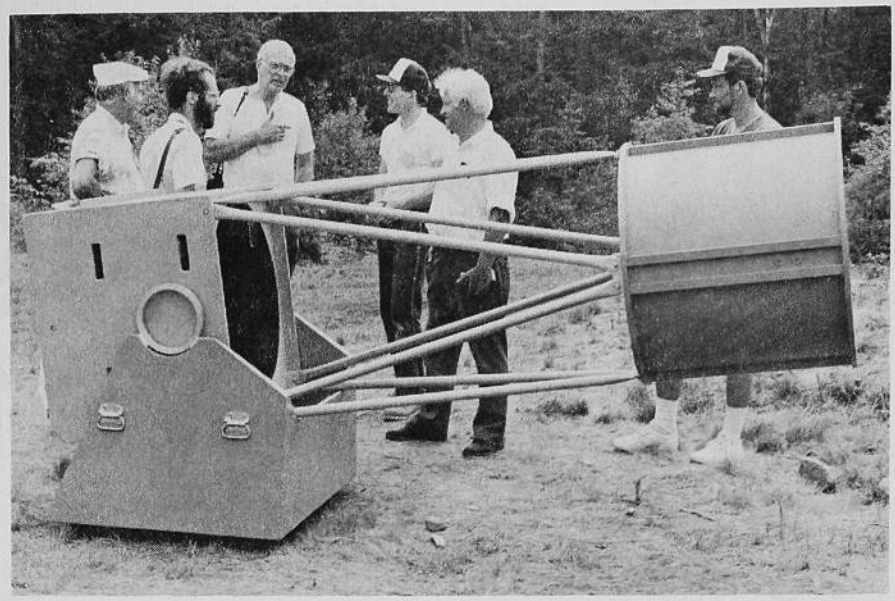
THE HONORABLE EDWARD SPENCER MILLER, ESQUIRE

JULY 25,1987

WE, THE STELLAFANE CONVENTIONEERS, WISH TO EXPRESS OUR APPRECIATION TO EDWARD SPENCER MILLER FOR HIS GENEROSITY IN ALLOWING US TO USE HIS FIELD FOR CAMPING AND PARKING DURING THE STELLAFANE WEEKENDS FOR MORE THAN 50 YEARS.

HIS GRACIOUSNESS IN PERMITTING US TO USE HIS FIELD HAS SIGNIFICANTLY CONTRIBUTED TO THE SUCCESS OF OUR YEARLY CONVENTION AND WE ARE VERY GRATEFUL.

SIGNED:



And the Idlenot is no more. There's still a restaurant in the old Idlenot spot--it's called a "Friendly"--but it lacks the lingering Yankee moralism that the word "idlenot" implied. Maybe it's too friendly.

Thus the new replaces the old, even at Stellafane, and we grow used to it.

--Richard Berry

Rolling Observatory

--or--

How a Trailer Can Make Observing More Practical and More Fun!

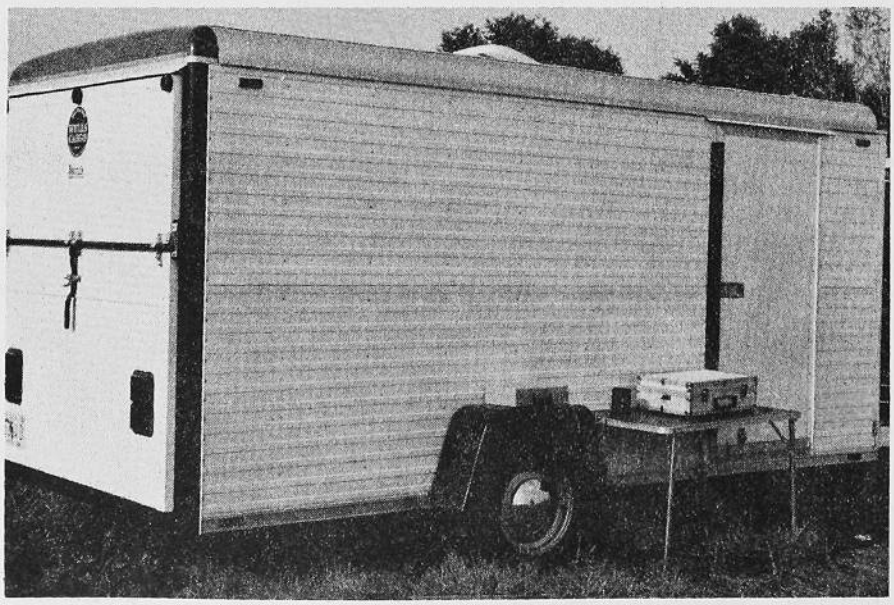
In this age of larger and larger telescopes, sooner or later we all have to answer that nagging question, "Just how much telescope am I really comfortable carrying around?" After all, it's only a matter of time before someone builds a portable 40-inch scope. Using these large scopes isn't the problem--it's a pleasure--but until now carrying them has been the problem. I have come up with a economical solution that makes it really easy to carry around almost any size scope your heart desires, and makes going observing a whole lot more fun and less work.

My first telescope was a little 13-inch Dobsonian. I'd only had it for about six months before I moved up to a 17-incher. I carried that 17 all over the country to star parties. It fit nicely in my full-size van, with plenty of room left over for all the things necessary for a night in the country under dark skies.

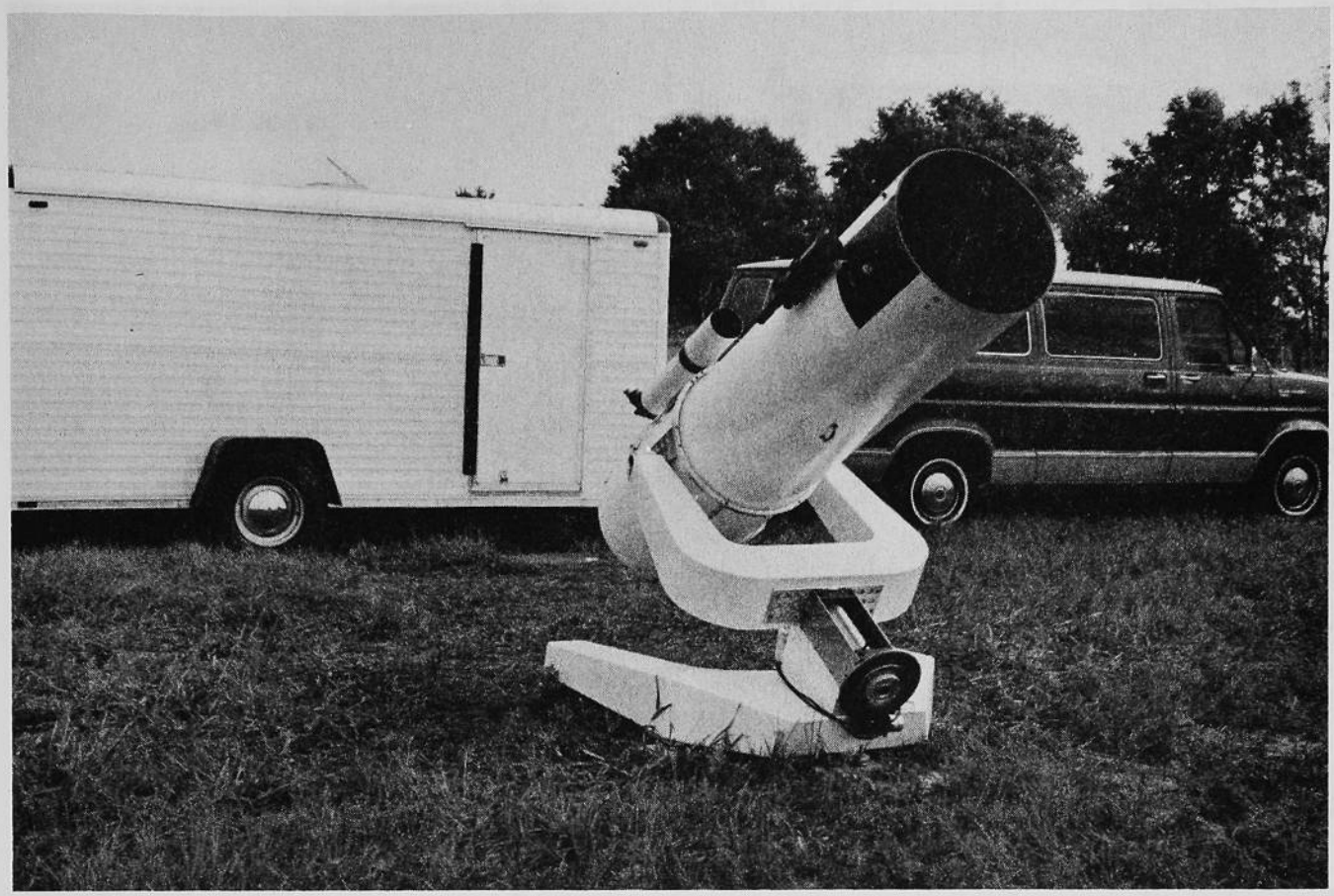
But after a couple of years of observing, it seemed like the check list of items necessary for observing was growing. (It's truly amazing how many gadgets we need to take with us.) When I started to go to star parties that lasted several days and on observing vacations, the check list grew even longer. Then I added camping gear to it.

By then, things were getting complicated. It seemed like it took longer just to load the van than the trip to the site. To add insult to injury, there always seemed to be one little item I forgot to take with me. Did you ever try to go observing without your eyepiece case?

Last year I finished building my new telescope--a 20 inch on a fork mount. No problem! I had designed



The back of the trailer drops to make a ramp; this makes unloading the telescope very easy. Note the access door near the front of the trailer.



Ready to observe--but without the usual hassle of unloading, taking out the telescope, and reloading for the night. This 20-inch f/5 telelscope weighs only 260 pounds, but it's still quite bulky.

the scope to fit in the van! My first trip with the new scope was to the North Carolina mountains in October. I loaded the scope and all the other necessary items, and off I went.

After loading and unloading the van several times I had a real system going. First I'd load the scope into the van, and then I'd oad all the rest of the goodies. When I arrived at the site, I'd unload all the accessories from the van so I could get to the scope to unload it. Then I'd put what I didn't need at the moment back in the van--Right!--so when it was time to go back down the mountain at dawn, I'd have to unload the van again so I could load the scope. Then I'd load all the other stuff again. I'm sure you're getting the picture by now.

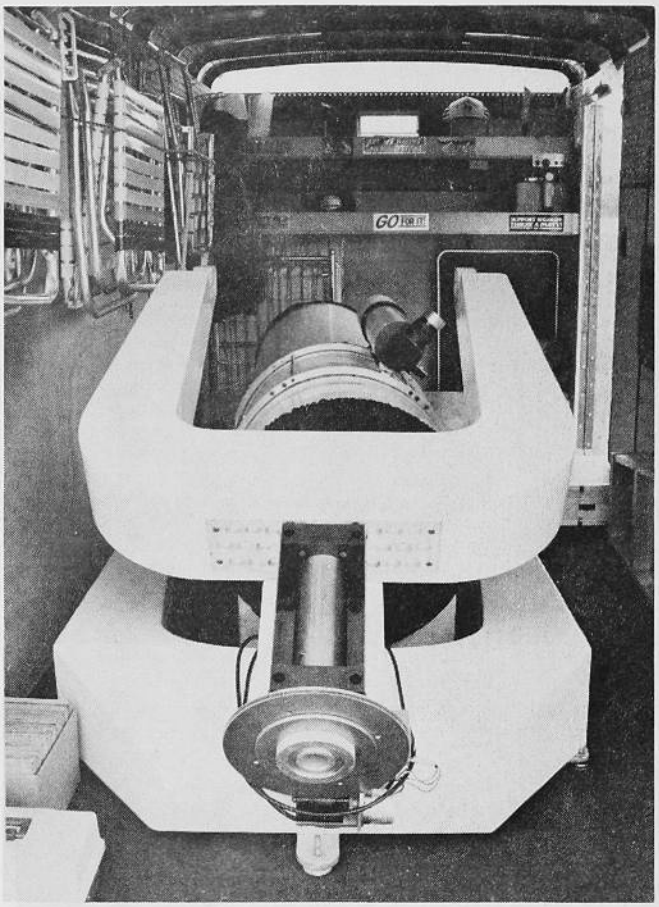
One night while sitting on the mountain top--in the fog--I got to thinking that there must be an easier way to enjoy astronomy with a large telescope. (You also tend to think of ways to keep warm when it's 30 degrees.) Wouldn't it be nice to have a warm place to climb into until the weather clears? An observatory was out. I don't live in a dark sky site and have no desire to move to one. Besides, I enjoy taking my scope to different sites and meeting people at star parties. But after seeing the views thru a 20-inch scope there was no way I was going to go back to a smaller scope again. I just needed a way to make toting the scope easier. And a way to keep warm.

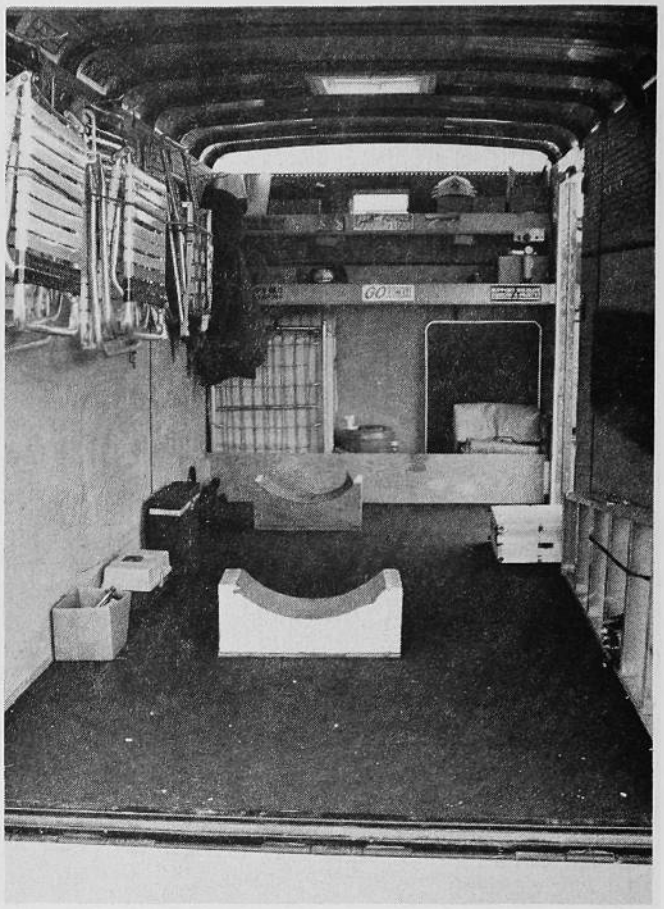
The answer to my problem came a week or two later. While cutting the grass in my yard, I noticed the lawn service people cutting my neighbor's grass. This guy had the most beautiful trailer I had ever seen. I drove the poor man crazy asking him questions..... How big is it?... What sizes do they come in?...How much do they cost?....How heavy are they?.....How do they tow?....How rough is the ride?...How hard is it to lift that huge back door?...Where can I buy one?

The next day I went to see the local dealer to learn more about these trailers. After looking through their catalog for several days, I went back and ordered one. Trailers come in any size from 8 feet to over 25 feet long. (Imagine the telescope you could carry in that!) The prices start at about $1000 and go up. It's similar to ordering a new car because you can get almost any type of option you can imagine. I ordered a 14-foot-long model so I would have room for a larger scope in the future. With the options I ordered, the price was about $2500. Compared to the price of a van they are a bargain. Just think, now you can have a 30 inch telescope and haul it around with anything you like to drive! Even a Corvette if you wish. Or maybe that motor home you've been thinking about!

I'm sure there are many companies around the country who build trailers like this. Mine was built by Wells Cargo, whose home office is in Elkhart, Indiana.They have additional plants in Waco, Texas; Waycross, Georgia; and Ogden, Utah. They have a toll-free number if you would like to to find out who your local dealer would be. 800-348-7553.

I picked up my trailer about four





As simple as ABC. Telescope tube is carried (left) on styrofoam blocks (middle) while traveling. Observing shelf is at the front of the trailer; note the stowed chairs, ladder, and cots.

weeks after I ordered it. It looked huge. The inside dimensions are 5 foot 9 inches wide by 13 feet 9 inches long, with a height of 6 feet- - and higher interiors are available. The model I choose came standard with plywood walls half way up and pegboard above that. The options I ordered include the ramp-type rear door. The door is full width and is hinged at the bottom. When you open the door it swings down from the top of the trailer and lays on the ground. It has a spring to act as a counterbalance so you can do it with one hand. The ramp makes loading and unloading a pleasure. When the trailer is not hooked to the van, the tongue has a small wheel that makes it real easy to roll the trailer around. Pushing it in and out of the garage is a breeze.

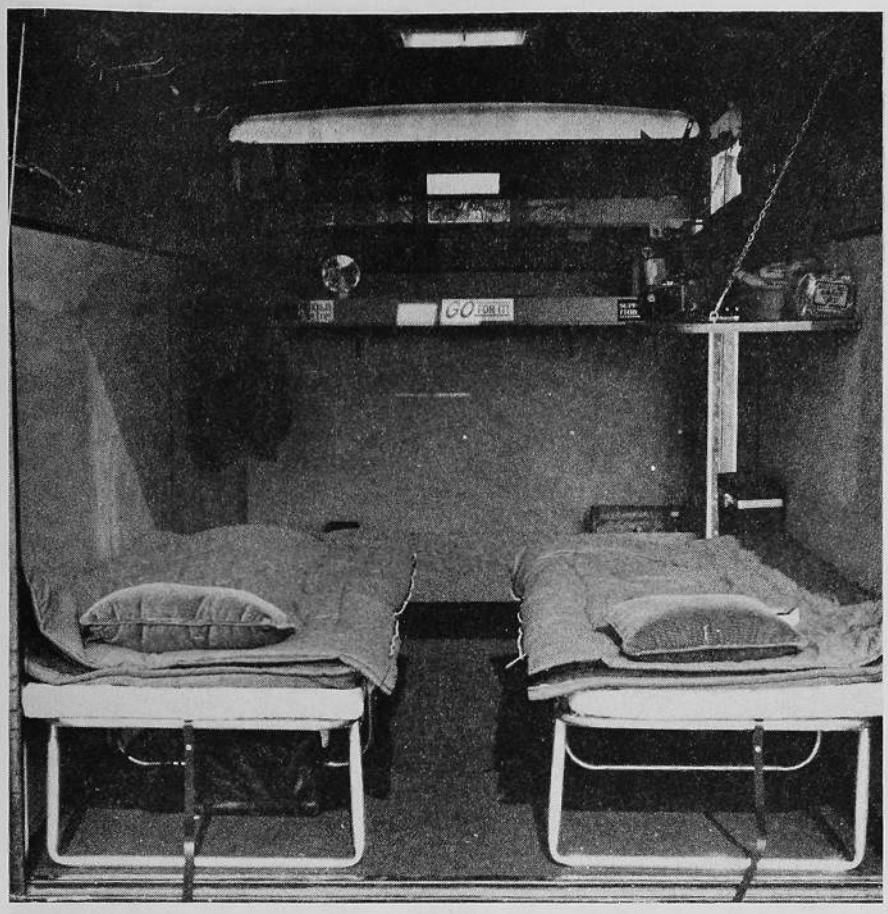
When the trailer lights were hooked up, I had them run an extra hot wire from the car battery so whenever the trailer is hooked up, it has power. This line is hot even when the car lights are not on. I purchased small red running lights and put one on either side of the trailer and two under the shelf over the chart table. The lights under over the chart table have simple shades made of cardboard, so the lights never shine in my eyes. On a trip to the junk yard, I found a 12-volt dimmer switch (an old headlight switch). This is wired in so I can make the red lights as dim or as bright as I want them.

An extra cigarette lighter socket completes the wiring. This is handy for 12-volt dew guns or running your radio off the car battery instead of small batteries.

The first thing I added to the trailer was a chart table with a small shelf above. The top shelf has small dividers so things won't roll around, and you can find things right where you left them. Under the chart table I added a removable 12-inch-high piece of plywood to hold things stored under the chart table. I made the area just the right size to hold my cots, heater, folding table, camp stove, and other odds and ends. Indoor/outdoor carpeting on the floor keeps the scope from sliding around while traveling. On the side of the trailer I made a table 16 inches wide by 5 feet long. A friend was kind enough to cover it with Formica for me. It is hinged on the bottom so it will lie flush against the side wall. When it is raised a small chain supports it on either end. This table holds all the necessities for observing till dawn: the stove, coffee pot, and food. (It's a good idea not to allow coffee cups on the chart table. Silly things always seem to happen around 4 a.m.).

For heat I found an old Coleman catalytic heater that runs on white gas. It really takes the chill out of the air on those long winter nights, and makes the trailer seem almost like a clubhouse. As many as a dozen people have climbed in to warm up. (Yes, it does get cold in Florida). It runs all night on about a dollar's worth of fuel. Of course I always leave the window and roof vent open a little so I don't asphyxiate myself.

The pegboard walls provide a nice place to hang clothes (no more putting on long-johns in the back seat), and also come in handy for storing the folding chairs. Hardware stores carry all kinds of



And space to sleep! Even with the cots open, there is still a 6- by 8-foot area for dressing. Cots are better the air mattresses because of the space underneath for storage. Note stove on wall.

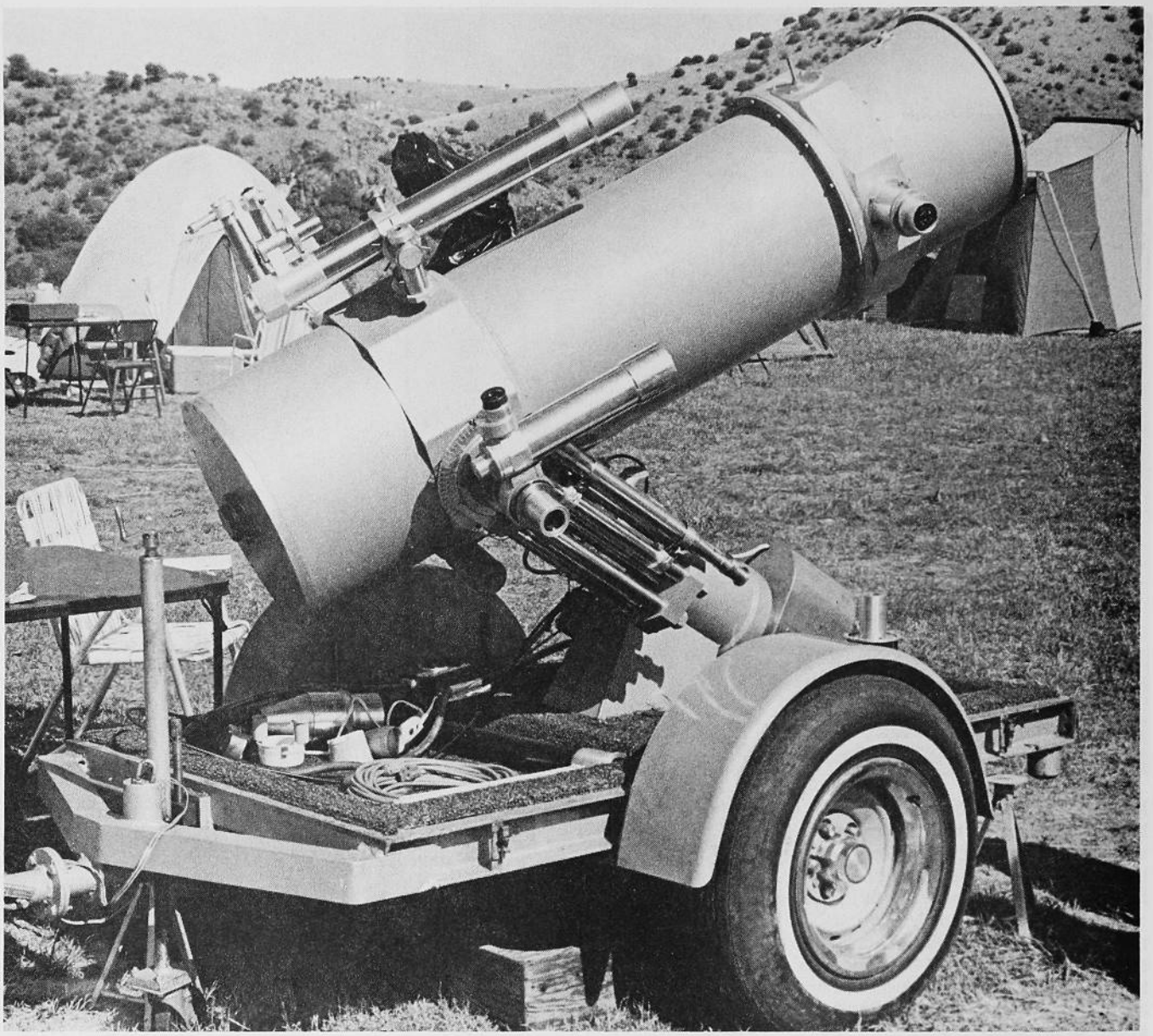
hooks for pegboard. I just put bungee cords over the chairs to hold them in place. Another bungee cord and hooks fit near the floor to hold the observing ladder.

When towing the trailer you really can't tell it's there. The empty weight of the 14-foot model is 1150 pounds.The only effects are acceleration is slower, and top speed is decreased somewhat due to the wind drag. The gas mileage also decreases a little, but it's not noticeable except on a long trip. Since I drive a van, I didn't think the wind drag would be so noticeable, so I didn't order the spoiler option for the trailer. Now it seems like a spoiler would have been a good idea. My van only has a six-cylinder engine, but I can still do 65 mph.

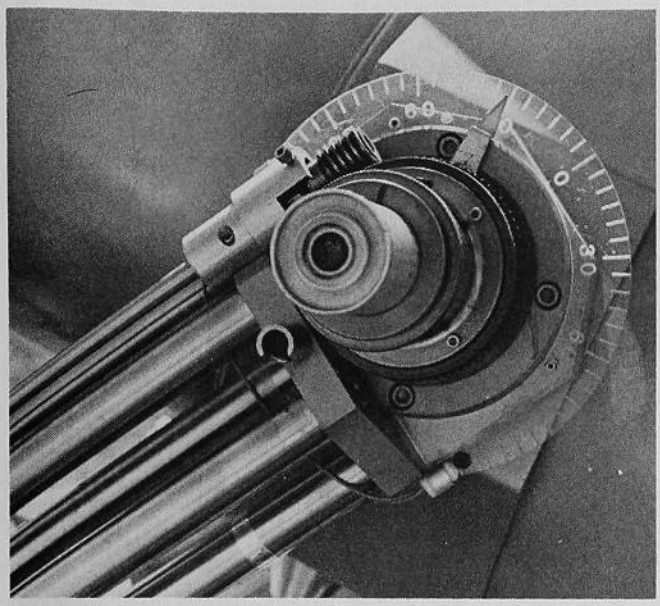
To sum it all up, I'm very happy with my trailer. The telescope now has a permanent home, and takes less of a beating because it is only loaded half as many times. If the sky suddenly turns clear I can be hooked up as fast as I can fill my cooler. Everything else is always ready to go. The trailer has drawn a great deal of interest at star parties, prompting writing this article. Several members of the local club now haul their equipment in trailers. One has a 20" f/7 Dob. The other has a C-8, but he sure has a lot of goodies in his trailer and enjoys it as much as I do mine. I know of other club members who are looking to get a trailer in the near future.

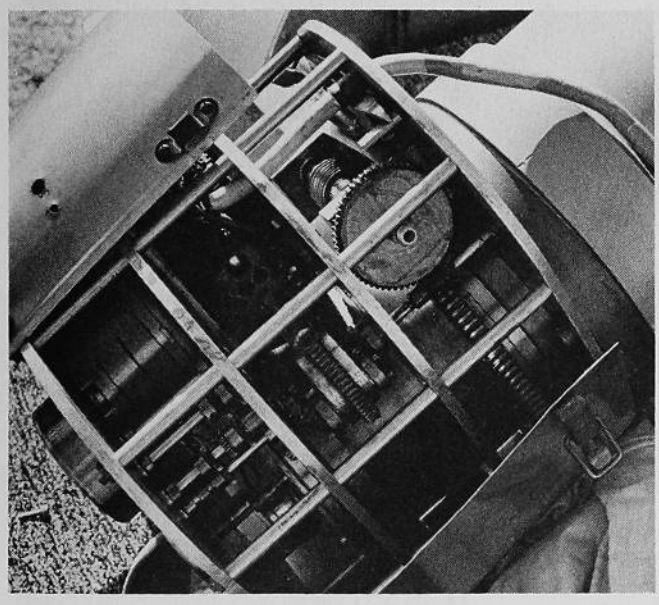
Hundreds of people at the Texas Star Party looked the trailer over very carefully. You could almost see the lights going on in their heads. There will probably be a lot more trailers there next year, hopefully along with many more large telescopes. After all, if you didn't have to spend $15,000 on a large van to carry it, think of how big a telescope you could have! Perhaps 30 inchers will be common before long.

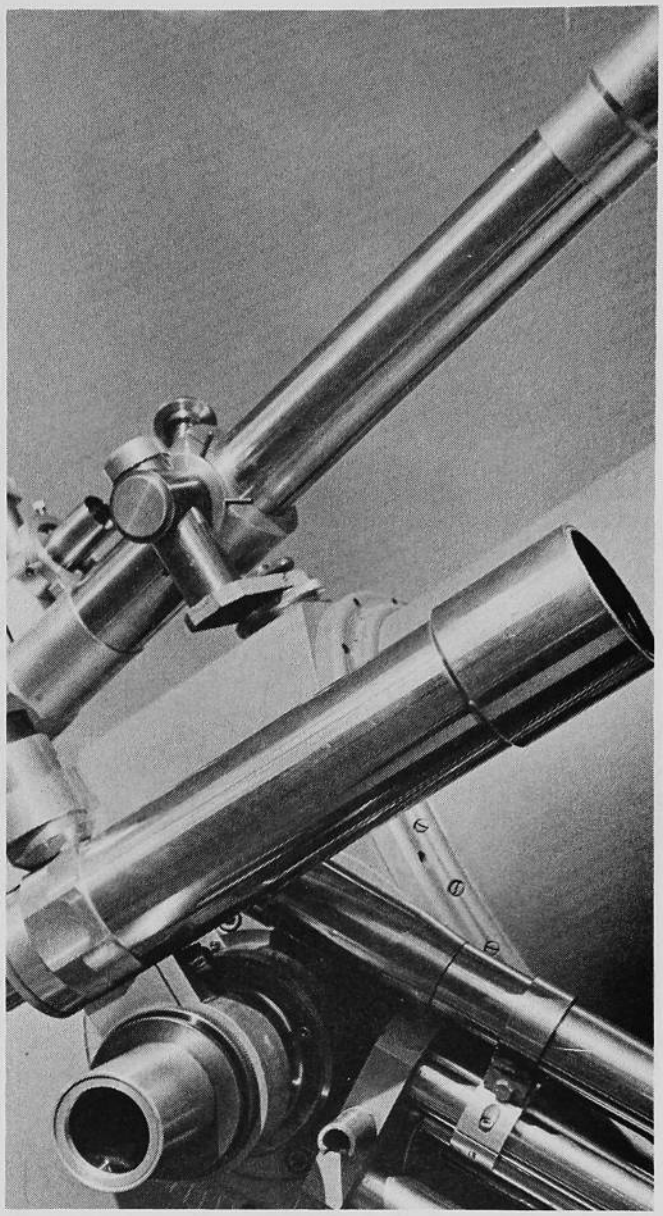
Tom Clark
2021 Whitfield Park Ave.
Sarasota, FL 34234



The Texas Star Party







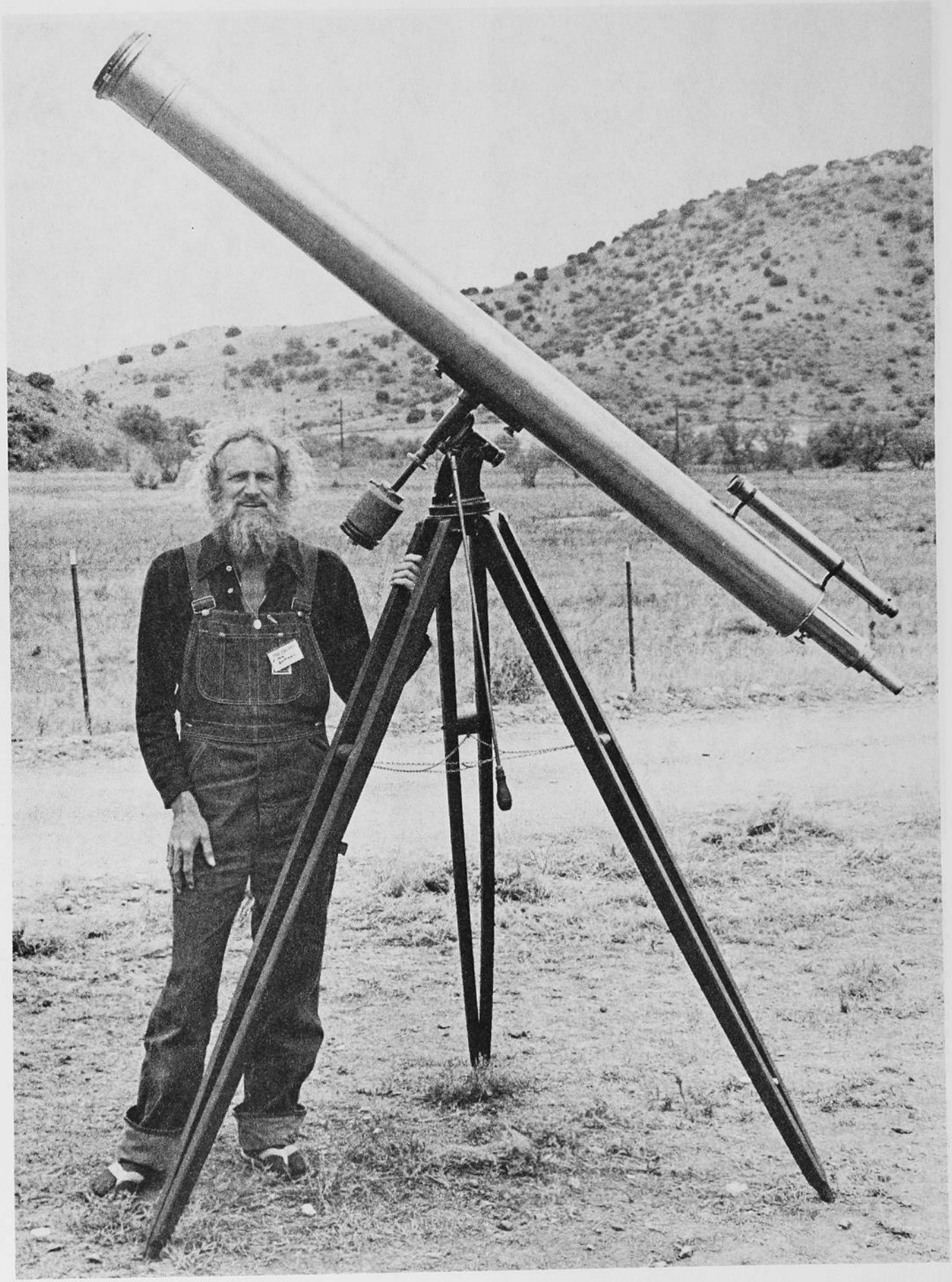
Dewey Burkes' 16-inch Newtonian-Nasmyth-Cassegrain attracted lots of attention at the TSP. A machinist by trade, Dewey spent the last two years working on this instrument. It's high-tech throughout: even to the tube, which is made from Air Force jet-engine containers. Opposite page: the telescope on its trailer; lower left: the polar axis with the drive mechanisms; top left: the western declination axis bearing with eyepiece; right: finders on the eastern dec bearing.

Despite a tornado that leveled a nearby town two days beforehand and variable cloudiness throughout the week, the 1987 Texas Star Party came off without a hitch. Held from May 25-30 at the Prude Ranch in Fort Davis, the gathering attracted 400 amateur astronomers primarily from the southwest, but a few dozen from other places as distant as England and West Germany.

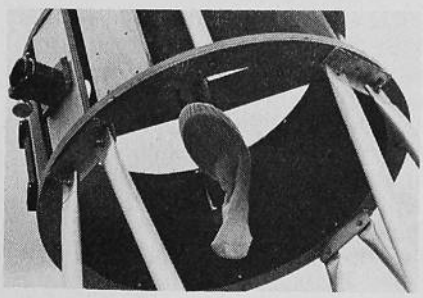
While the emphasis at the TSP is more on observing than it is at Stellafane or Riverside, this year the Texans drew several innovative telescopes. Perhaps the grandest was Dewey Burkes' trailer-mounted 16-inch scope that operates as a Newtonian or a Nasmyth-Cassegrain. Dewey, a jovial amateur telescope maker in his sixties, has operated a machine shop in Pasadena, Texas, for the last forty years. During the last two years he designed and constructed his 16-inch using aluminum airplane scrap. The scope sits on a sturdy equatorial mount and, resting on the trailer, resembles an antiaircraft gun ready for service.

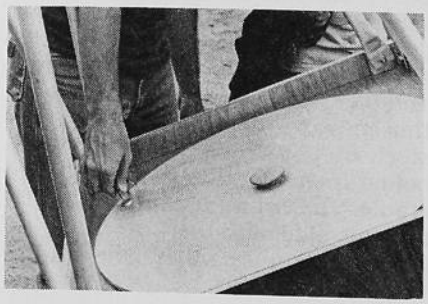
Dewey built his telescope to be comfortable to use. When he uses it as a 16-inch f/4 Newtonian, the secondary mirror can be rotated to send starlight to an eyepiece on either side of the tube. When it is used at the f/16 Nasmyth focus, Dewey can direct the light through either declination axis. This allows observers to choose whichever side offers the most comfortable view depending on the telescope's orientation.

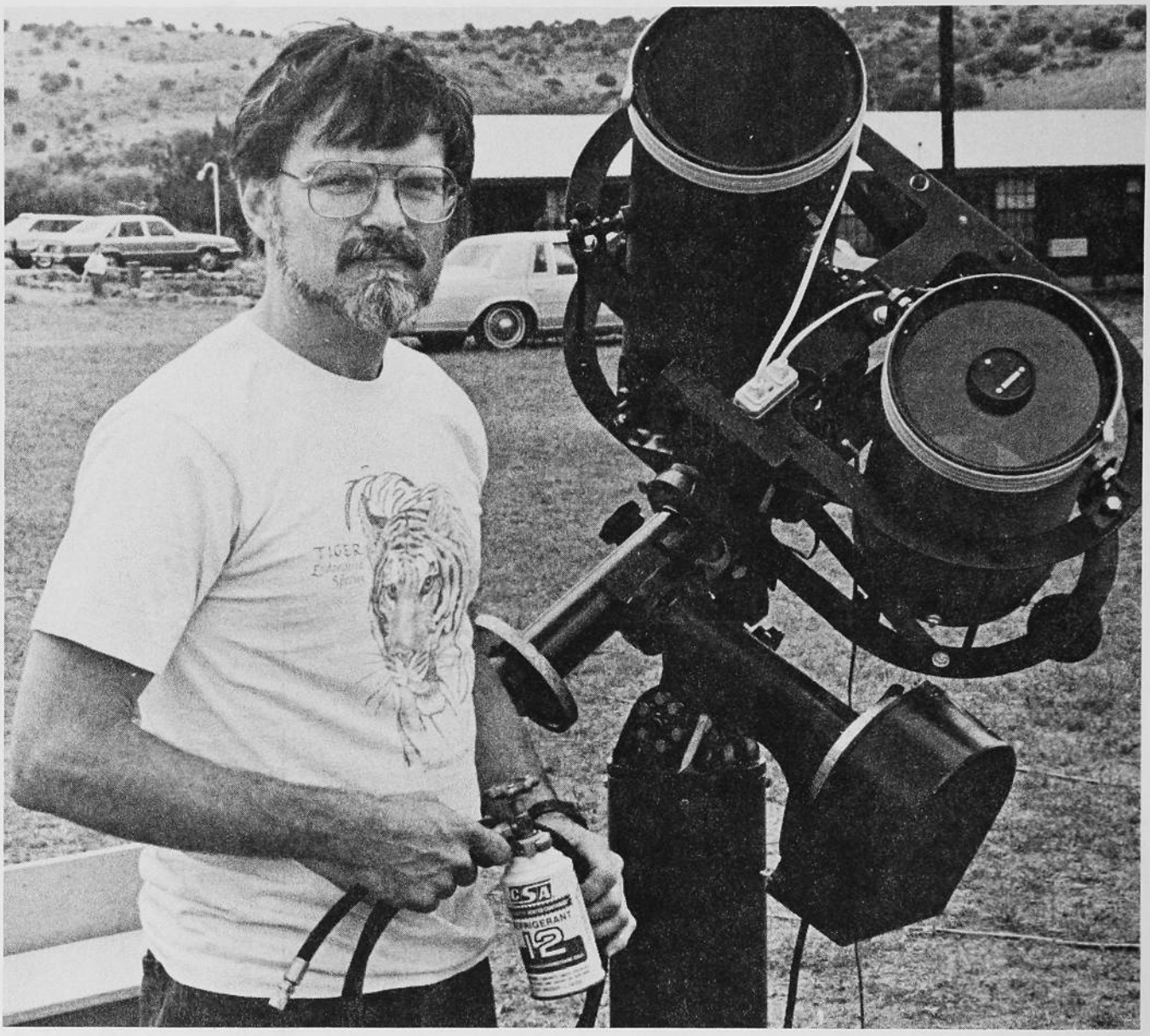
Atop the scope sits a 3.25-inch guidescope for photography, and a 3.25-inch finder rests on the right-hand declination bearing. The machining, execution of assembly, and maintenance of this scope are magnificent. Its recessed Allen bolts, Plexiglas setting circles, clean, tight-fitting gears, hand-tightened adjustable finder



Opposite page: Jack Eastman brought a touch of the last century with his 6-inch f/15 Clark refractor. Eastman has the original case for the instrument. Above: David Higgins and Philip Scott had the biggest telescope at the 87 TSP. The 24-inch Dobsonian has an open tube that is normally covered with a black cloth shroud to help image contrast and eliminate scattered light. This telescope drew a large crowd of serious deep-sky observers. Right: The diagonal cover and mirror cover.







clamps, and other features impressed all onlookers. The telescope is absolutely gorgeous, and Dewey delightfully shrugs off his masterpiece by saying, "Now that I've built it I need someone to teach me how to use it."

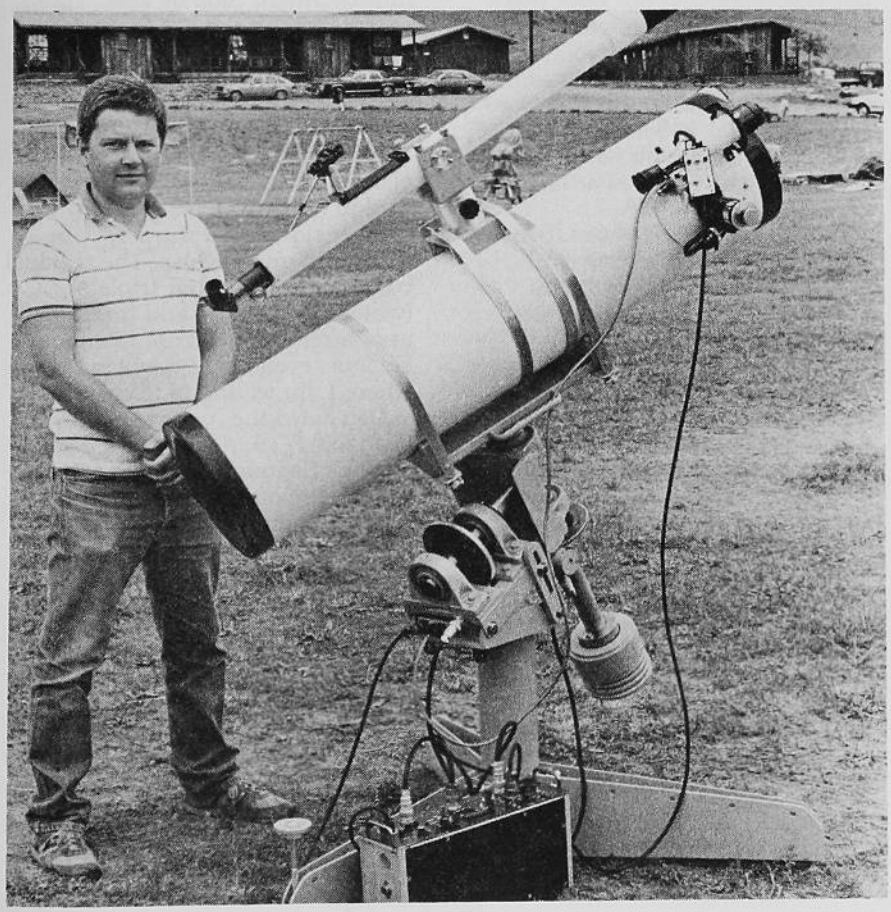
On the photographic end of things, Robert Reeves of San Antonio brought his homebuilt photo system that features an 8-inch f/1.5 Schmidt camera and 8-inch Schmidt-Cassegrain guidescope. The pair rests on an old Cave Astrola equatorial mount and pier. What's homemade about this setup? Robert welded two steel, theta-shaped plates and bolted them together to form a cradle. The Schmidt camera fits into one side, and the C-8 guidescope in the other. The cradle holds such conveniences as a plug block that feeds nichrome wire to the front ends of both units, thereby eliminating dew, and aligning bolts to maintain collimation between the two instruments and to find guide stars.

Reeves is a believer in low humidity, and to that end drilled two holes in his Schmidt camera tube, fitted them with valves and rubber tubing, and flushes the tube with dry gas before photographing to maintain low humidity. Reeves used to use Freon, but has recently switched to dry nitrogen because he found that Freon caused odd-shaped and enlarged images.

Simple in design yet effective, at least from a deep-sky observer's standpoint, is the 24-inch f/4

Robert Reeves stands beside his dual 8-inch Schmidt-Cass/Schmidt camera astrophoto rig. Reeves uses a dry gas to prevent absorption of moisture by the hypered films he shoots--he does this by flooding the interior of the camera with it. Reeves advises, "For the gas, use nitrogen, not Freon." To combat dewing, Reeves uses electric heaters on the corrector plates of both instruments. A detailed report on this rig was published in the December 1987 issue of ASTRONOMY.

Dobsonian brought by Oklahomans David Higgins, John Elrod, and Philip Scott. The largest telescope at this year's TSP, this mammoth instrument drew lots of observers and lots of praise. Joe Pearson and John Dutton of Oklahoma City used optics from Paul Jones of Star Instruments and a design similar to that used



Top: This 10-inch f/5.6 equatorial Newtonian features 2-inch steel shafts, Mathis gears, and a bright yellow paint job. Mark Komsa of Houston assembled the unit from scrap materials. Bottom: A nested-corner platform (see TM#14 and Chuck Oldson's modification in TM#15) shows up in Texas! Built by Eric Allen and Rick Harris (in photo), the 10-inch Newtonian tracks like an equatorial. Says Harris, "I can get 18 minutes of accurate tracking before I have to reset."

by Sky Designs. The front and back ends are made of wood, while the open tube struts are aluminum. To keep stray light from interfering during observing, Higgins and crew use a black velvet cloth held in place by strips of Velcro. To keep the secondary mirror clean, they cover it with a sock. A wooden mirror cover locks the mirror compartment so that no unauthorized observers can use the instrument or scratch the mirror surface. The execution of this telescope is first-class, and the telescope's performance attested to the mirror's quality. I used this scope extensively for observing and sketching faint deep-sky objects, and I think it is one of finest Dobsonians owned by a group of amateur astronomers.

Well-known astrophotographer Jack Eastman brought a historical gem from his home in Sheridan, Colorado. As I walked by one hot morning, Jack was uncrating his 6-inch f/15 Alvan Clark refractor built in 1877 (and still in the original crate!). This scope's tripod was a little shaky, but the optics provided fabulous images of double stars and planets. The telescope was obtained by Jack after a dealer purchased it from Kentucky's Center College, the scope's original home.

Even though the majority of nights were cloudy or presented us with patches of sky for a few minutes at a time, the usual nighttime talking and observing went on. Ed Boutwell played his now-famous tape *Chariots of Ducks* in an attempt to ward off the cloudy-sky gods, while David Levy searched for Comet Halley, Brian Skiff expounded on deep-sky data, and Clyde Tombaugh recounted his discovery of Pluto. All things considered, everyone seemed to have had a wonderful time.

-- David J. Eicher

Optical Experts Comment on the Texas Star Party

Dick Buchroeder, Dean Ketelsen, John Gregory, and Richard Sumner talk shop

This year four optical professionals -- Richard Buchroeder of Optical Design Service, Richard Sumner and Dean Ketelsen from the Optical Sciences Institute (all in Tucson, Arizona), and John Gregory of Gregory Optics in Dripping Springs, Texas -- attended the Texas Star Party to compare and evaluate the "high-end" optical instrumentation at the meeting.

Their reports, originally written as letters to TM's Robert Cox, comprise a fascinating commentary on state-of-the-art optics for the amateur mixed with behind-the-scenes optical gossip. It is important to keep in mind, as you read their comments, that they were actively looking for the slightest residual aberration in the telescopes they examined.

Richard Buchroeder: "Sumner, Ketelsen and I left Tucson Thursday morning and arrived about 5:30 p.m. We set up a Sumner's 4.5" f/20 doublet Apo (SSK3 and KZFSN4 glass types), and my 6" f/12 Christen Apo. The weather had been poor for several days before we arrived, and there were broken clouds and some rain Thursday night. Although Friday night was clear, the dew was thick and troublesome for the refractors, at least. People at the observatory said that the weather was unusual, as it has also been in Tucson and elsewhere this year, but that this was actually a rainy season anyway in Texas. The sky was almost bright enough to read headlines by. We were unable to get an explanation from anyone as to why it was so bright since there are no major cities for a very long distance.

The seeing was not bad, but not very great either; but it was certainly better than Riverside. We were able to push an 8-inch to its limits, but the seeing couldn't do justice to a 12.5-inch scope.

Now to the apos. There were four lined up in one spot and Gregory named it "apo valley". We had a 6" f/8 from the Ponchartrain group, made by Christen, my 6" f/12 also by Christen, the 4.5" f/20 made by Sumner that I designed some years ago, and John Gregory's 8" f/15 (see S&T June 1987, page 662). The Sumner lens isn't quite finished, nor is the Gregory, but both had been pushed into service so we could have a chance to compare them at TSP. Sumner's has some cell problems and John's shows some residual spherical aberration. Although neither was coated, neither showed a hint of ghosts.

There were at least two other significant apos elsewhere on the grounds: a Takahashi 100mm aperture f/8 fluorite lens, and a Christen 6" f/9 (yes, f/9). I only briefly looked at the moon through the Takahashi and it did indeed neatly correct the color, and in fact it should do much better than the three-element Christen-type lenses are capable of doing since it uses fluorite, which is akin to Gregory's FK52. My old compatriot from B&L, Al Bowen of the Dallas area (TM#3, page 14) owns the 6" f/9. It was made around 1983 by Christen before he got down to f/8. It showed nearly perfect diffraction images, except for some astigmatism (which was not due to my eyes; everyone saw it in several different eyepieces with thru-focus and in-focus tests). When we quit testing and looked at some objects at lower powers, we found it was a magnificent lens. It is said, or rumored, to use the equivalent of KZFS1 rather than KZFSN4, whose partials are somewhat different.

Its secondary or residual spherochromatism seemed to be noticeably lower than of the 6" f/8 Christen design that uses, we believe, KZFSN4. None of us could say whether this was due to the different partial dispersions of the two glasses, or whether simply slowing down to f/9 from f/8 would make that much of an improvement. Side by side comparison of the 6" f/8 Christen with the 6" f/12 left no doubt in anyone's mind about the superiority of the slower design.

However, we were all shamed by Gregory's 8" f/15. It uses superior glasses in an even slower design. I couldn't, by all efforts, see any color residual in John's system, nor could anyone else. The residual color in the Christen triplets (which are normal and traditional apochromatic designs) is quite obvious, even at f/12, which is where I am willing to tolerate it.

Also down the road were a 6", probably f/15, Alvan Clark owned by Jack Eastman, and a 6" f/15 Clave. (Of course we don't even need to discuss the secondary color in those.) I was unable to do much testing of the Clark as Eastman doesn't believe in using a star diagonal, and the Clark tripod mount is quite shaky, making critical testing all but impossible.

I did a little in-out focus testing of the Clave but was unable to make any critical judgments because at the time seeing was too

poor. There was also a 6" f/5 Jaegers lens on the field. It was fun to see its residual color, which at low power is actually quite tolerable. There is some questions in my mind as to the necessity of apochromats when the power is low, but that is a design discussion.

The Gregory apochromat, with its superbly made modified-Springfield mount, was wonderful to use. It has a fixed eye position and the mount was steady. John uses three folding mirrors of variable quality. It surpassed all other refractors of all types on the field, no question. Its perfectly colorless image was definitely an asset, I think, in achieving this. I tremble to think what it will do when he removes that last remnant of spherical aberration by aspherizing one surface. The correction was partially done, but not completed, in time for the meeting. The spherical aberration was strong enough that I could not see Fresnel rings on both sides of focus.

I also got a chance to look through a 3" apo, the Oracle 3 f/7.4 from Televue. It was set up indoors with a low- to moderate-power eyepiece and was looking through a window at the hills. Its image was afflicted with a slight magenta hue, suggesting excessive secondary color.

Vernonscope now offers a 92mm f/7 apo which Don Yeier tells me has optics by Christen, despite the name "Brandon." I know that at least some the big boys are once again considering resurrecting imported apos, this time with FK type glasses, of even shorter f/ ratios. Alas, magenta hue and spherochromatism are here to stay, but let us hope that we can at least produce a few quality instruments among the flood of second-class consumer-demanded short-tubed telescopes.

"...at least there are a few telescope makers left in the world, and it is to them that we will probably owe whatever technical advances are made in high-quality optics."

I was able, at last, to lay my hands on a Nagler Type II 16mm ocular. There were a lot of Nagler eyepieces on display at the vendors during the day, but I only found this one 16mm on the field at night, fortunately next to the 6" f/9 apo. The owner was also willing to let us take it, with him in tow to guard it, to our apos down the road. The Type II design indeed corrects spherical aberration of the pupil (but not all pupil aberrations, Al), which made it possible for me to use. But I was dismayed to learn that not only does it provide too little eye relief for me to wear my glasses (I have astigmatism), but that it produces three or four bright ghosts when used on Vega.

The eye relief is too short even for me or my two colleagues to see the field stop without eyeglasses, so the value of its 82 degree field is somewhat moot. Looks like there is still some room for improvement in the design.

The 12.5" f/21 Tri-Schiefspiegler made by Steven Johnston (see TM#28, page 44) was there, too. We had some fine views of Saturn with it Friday night around one a.m. when the seeing was at its best. I intended to mask it down so we could do a 1:1 comparison with Gregory's 8" apo (FK52 and SK16 glasses), but as usual time slipped away and it didn't get done.

As you know, that Schiefspiegler is one of my own designs so I can't be trusted to be objective about it, nonetheless, it was apparent that due to sheer aperture and excellent work by Johnson, it did better than my 6" f/12 apo, and seemed quite close to Gregory's 8" f/15 apo, at least to me. Dean and Dick told me as were driving back to Tucson that they felt that the Schiefspiegler showed more detail on Saturn than did the 8" apo, during those fleeting moments of good seeing at 1 a.m. I think we are starting to reach theoretical limits where size rather than quality, makes the limiting difference.

That just about covers the high-tech end of the business. Pierre Schwaar, who has done work with Image Point in Tucson with their BigFoot mounts was there with a 10" f/7 eccentric pupil paraboloidal Newtonian he has made directly as an off-axis section, but he needs to improve his technique before that becomes a viable telescope.

There were thousands of Dobsonians and SCT's in red. blue, and black tubes. Approximately 5 percent were home-made telescopes; all the rest were store bought. Still, at least there are a few telescope makers left in the world, and it is to them that we will probably owe whatever technical advances are to be made in high quality optics. I can assure you that I wouldn't come to these

conventions if it weren't for that minority.

Based on my examination of Gregory's telescope, folding a refractor -- despite the fact that it reduces the height of the objective to some 5 feet above the ground and introduces the danger of image deterioration from the three flats -- did not to make the 8" inferior to anything else of the same aperture. And this was in spite of incomplete aspherizing.

Furthermore, the light loss from the three reflections and uncoated objective, plus the usual eyepiece losses, didn't prevent the telescope from giving beautiful deep sky views. Obviously, there is a serious light loss, but if we can get some stable, probably all-dielectric enhanced reflection coatings instead of the enhanced silver, which rumor has is unstable, then folding a refractor to reduce its size and volume should be quite permissible provided quality components are used throughout. (I expect that most telescopes perform poorly just because of poor quality components.)

But once you've put one reflection, much less three, in an optical beam there is no obvious reason to believe that it was necessary to have a refractive objective in the first place. Consequently, we get back to the arguments in favor of unobstructed all-reflective, or even unobstructed catadioptric designs. I would guess that the problem, if there is one, with unobscured designs lies in component and assembly alignment tolerances in most cases. Effort should therefore be directed toward improving these.

A window is probably another important advantage of the refractor: it keeps the optics clean. Anyone who has looked through some old Newtonians is aware of the glow that results from dirty optics. Obviously, a dirty window can cause trouble too, but since it is easy to reach, it is likely to be cleaned. A hard-to-reach mirror will probably not be cleaned.

The drive to produce fast, compact optical designs results in decidedly more sensitive tolerances. In the case of apos, it precludes eliminating spherochromatism and keeping the cost of superior designs with in reason.

I noticed, too, that recrossing light paths in the folded refractor did not result in any noticeable loss of image quality under TSP conditions. Art Leonard has claimed that a big advantage of a refractor, unlike a reflector, is that the light comes down the tube only once, not twice, minimizing tube current influences.

The 12.5" Tri-Schiefspiegler gave the 8" apo good competition when seeing was good, and I myself having experimented with other Schiefspiegler types have found it quite possible to get identical patterns inside and outside of focus, even with amateur-quality workmanship (i.e. my own). However, the argument that big telescopes can never be commercially successful is regrettably probably true.

Likewise, when telescopes becomes too expensive, it is also apparent that they cannot be sold in the mass market even if they are perfect. This means to me that only serious amateurs will ever have first-class telescopes. But even if first-class telescopes can never be commercially viable, it remains for someone like the Zeiss works (or Gregory, Nagler, or Christen) to produce a limited-production telescope that is not intended to be a commercial success but is intended only as a personal achievement, a monument to excellence without bowing to practical considerations. Believe me, it is such a joy to look through one of these instruments that you'll be glad you did it.

I am sending copies of this letter to my Tucson friends and also copies to Al Nagler, Roland Christen, and John Gregory, since I discuss their work or products, not always benignly, but with due effort at being objective and accurate. They still have some improvements to make despite the excellence of what they have already accomplished. What I say is my opinion, and I'm entitled as much as anyone else to express it, including in printed form.

Robert Cox: Back at Stellafane 1956, I had the opportunity to photograph and later publish an article on John Gregory's Maksutov-Cassegrain telescope. It is a pleasure some 31 years later to see that he has again made an optical system that in its performance rises above its peers.

John Gregory: TSP was indeed a high water mark to date for apos, and the two hours of moderately good seeing Saturday morning -- 12:30 to 2:30 -- made it all worthwhile.

My "objective-subjective" comments are identical to Dick's regarding the 8" f/15, the 6" f/12, f/9, f/8 Christen apos, and the 6" f/15

Clark and 6" f/15 Clave achromats. You should be aware that on Thursday evening between 8 and 9:30 p.m., with insufficient cooling down time, the 8" showed bad tube currents relative to the straight-through apos. It had been in the car soaking up heat and had greater delta-temperature than others. Friday evening it was athermal by the time good seeing arrived. The 5" and 3" folding flats are excellent in figure, polish, and coating, but the 2" is up for replacement due to scattering.

The 4.5" Buchroeder doublet apo had almost no visible color except violet, like the Christen 6" f/12.

My glimpse through the Johnston 12.5" Tri-Schiefspiegler was at 2:30 a.m., when the dew was dripping from the eyepiece. No comparison would be fair under such conditions. Because the eyepiece is intentionally tilted so as to focus the full field of view, the pupil is automatically decentered and requires the eyepiece to be corrected for a fully centered beam some what faster than the f/21 of the instrument. This poses no problem for most modern oculars.

With Vega in the morning sky, we took a 1/10" ocular and tested the 8" f/15 with its 4" f/9 (BaLF6-KzFS1-SSK6 glasses) finder telescope. Racking through focus, the 8" was free of color, while the 4" showed the violet rim inside and at focus, with a green disk outside focus, just as all cemented apos will (see S&T, June 1987, page 663). This must apply to Vernonscope's apo, the Oracle 3, and Christen cemented apos too.

The Nagler 16mm Type II worked beautifully on the 8" f/15 (200X, 1mm exit pupil). With that small an exit pupil my astigmatism doesn't show, so I opened my eye wide and plunked it close to the eyelens. No off-axis astigmatism was visible at f/15, and I could just see the field stop. I'd gladly trade down to a 70- to 73-degree apparent field of view for more eye relief, but I don't know if such a tradeoff is possible without reintroducing other problems. Anyway, the view was superb for me.

> "...it remains for someone to produce a telescope that is not intended to be a commercial success but only as a personal achievement, a monument to excellence"

Robert Cox: Richard Sumner is the Optical Shop Manager at the Optical Sciences Center in Tucson. He brings years of professional experience in the fabrication and testing of optics to his evaluation of TSP optics.

Richard Sumner: I was was disappointed, as was Richard Buchroeder, with the mix of telescopes at the TSP. Far too large a percentage were merely purchased units. Although they may have been fine instruments and their owners had a good time using them, I have always felt that it more fun to make your own to feel the accomplishment of displaying and using the product of your own effort.

The units which I had the pleasure of using were the Gregory 8" f/15 and the three Christen units with f/8, f/9, and f/12 focal ratios. I gave each a good look and I must agree with both John and Dick, that the longer focal lengths seem still to have an advantage in performance.

I also had the opportunity to use the 12.5" tilted-component Schiefspiegler and was very impressed with the high degree of workmanship and the overall performance of the unit. In fact, I felt that on low contrast subjects, like Saturn, that it outperformed some of the refractors under the dewey conditions that prevailed.

The TSP was this year so large that a person could wander off and not be seen for several hours. This is great fun, but it is no way to compare critical parameters of a new offering. I would hope that an area be set aside for people who have brought units of unique design, or that represent an advancement in the state of the art, could set up these units. It would be an attraction that would honor the person who has gone the extra mile. It would also make it possible for the judges to be more objective in their review of the units presented.

Robert Cox: I have had the pleasure of personally knowing the above three gentlemen for many years and had important and interesting meetings in which they were present and exciting correspondence on optical matters. The last person mentioned earlier, Dean Ketelsen, I haven't had the pleasure of meeting.

Dean Ketelsen: This was my first trip to an amateur gathering of this kind, but I've done lots of observing, having worked at Kitt Peak for over five years and used literally all the telescopes, from sky-limited photography at the 4-meter prime focus to observing Jupiter and Saturn on open nights on the Solar Telescope. Most of my amateur viewing has been done with Newtonians, and I've got a 6", 11.25", and 12.5" of my own.

Lately I've been working at the Optical Sciences Center doing rapid figure generation of large optics with the Large Optical Generator, so I've gone through a bit of a career change, but I am still involved at the amateur level.

A top-priority job I am involved with right now is a 30" lightweight casting that was donated to the local amateur club by Roger Angel's spin casting group. I generated it on LOG and will polish it over the next months. I work with Dick Sumner and when I heard he and Buchroeder were going to the TSP, I talked him into taking me along.

I was disappointed in the small number of amateur built telescopes there, and the resultant innovation I expected to see. The main reason I went was to get ideas for the multitude of plans I've got and there was little I hadn't already seen in local amateur circles.

Steven Johnson's Schiefspiegler and John Gregory's doublet apo were the lone exceptions to the above lament. Gregory's telescope, in my opinion, is the ultimate example of the telescope maker's art. In it he combined optical and mechanical excellence. Too often a good instrument is reduced to average by a poor mounting, but his torque-tube mounting with the folded refractor ending in a Springfield arrangement was vibration free and motor driven on both axes, a truly perfectly excellent design.

Then it was all topped off by the fact you could look through the finder (a cemented-triplet apo) or use the setting circles without taking your eye from the eyepiece. The optics gave an image as colorless as the reflectors I'm use to using. We were saw atmospherically induced colors in bright stars 40 degrees above the horizon. Vega at the zenith was absolutely colorless. Unfortunately I did not do a lot of observing with the apo, the exception being Omega Centauri and Saturn when Sumner and I were making our comparison of the 8" apo with the Tri-Schiefspiegler (described at length in the Buchroeder account).

Mostly, it seemed to me, people were looking at various out of focus images of bright stars, which is certainly a demonstration of a telescope's performance, but not particularly exciting after the second or third time. In my grad class at the Optical Sciences Center last semester we spent days, if not weeks, on diffraction and observing diffraction rings in the lab, so I was quite familiar with the test and how to apply it.

I didn't discover Steven Johnston's Tri-Schiefspiegler until my last night at TSP. Until I found it, the view of Omega with the 8" apo probably the best I've had. For some reason, there was no one there waiting, so it was just me and him, a real optimum situation to see what the telescope could do on a variety of objects. I was really impressed by the telescope. The more I used it, the more impressed I became. Like most amateurs who have built large reflectors, I'm used to f/4 to f/6 Newtonians. This one was f/21, so when I first walked up I expected it to work well on lunar and planetary objects, but not much else. Boy, was I wrong!

With a wide field 1.25" eyepiece, the magnification was about 200 power, and Omega was well over three spectacular fields of view across. That ranks right up there on my list of unforgettable sights through a telescope.

We followed that with a very good view of the Owl Nebula, where the 'eyes' could be seen quite clearly. Messier 65 and 66 were similarly well shown with a wealth of detail.

By the time I had spent an hour with Steven and his telescope I had another project I wanted to build. The only disadvantage I saw in the instrument its uncomfortable eyepiece position for very low objects and the lack of an equatorial mount. The Dobsonian mount he had was smooth working and objects stayed in the field for a surprising length of time at 200x, but it is a large telescope and would be more convenient to use 'hands off'.

I am not certain what it is that makes the 8" Gregory apo and the Johnston Schiefspiegler so remarkable, but it is probably a combination of the long focal ratio and subsequent higher magnification which darkens the background, the unobstructed aperture providing just a bit more light, the lack of secondary and spider diffraction, and the smooth

spherical surfaces with little microripple, which, as we know, reduces contrast when it is present.

Even though the primary of the Tri-Schiefspiegler is an aspheric, it has a correction 55% that of a corresponding paraboloid, and the shallow curve (R=300" on the 12.5") allows one to work the surface with lots of pressing between polishing spells, reducing microripple to a minimum.

Our critical comparison of the 8" apo and TCT on Saturn I will summarize by noting that color differences appeared more distinct in the Schiefspiegler, but the Gregory apo gave slightly sharper details. The comparison was made at very similar magnifications with most surfaces dripping with dew. The telescopes were about 50 feet apart, Gregory's about five feet higher. The seeing appeared worse in the TCT, possibly because of tube currents.

The rest of the instruments were pretty ordinary. I did some observing with some Dobsonians of 18" or so aperture. Nothing too surprising except some observations of small dark nebulae seen against the star clouds that some folks were making.

One other notable telescope was the 10" f/7 of Pierre Schwaar brought from Phoenix. By looking at the Foucault pattern of a masked-off 16" paraboloid, he figured a 10" as an off-axis paraboloid, no easy feat for a amateur telescope maker. Though obviously not perfect when tested on bright stars at high magnification, it worked quite well at lower powers on deep sky objects. Masking it off to 8" clear aperture gave us fine views of Saturn.

"This one was f/21, so when I first walked up I expected it to work well on lunar and planetary objects, but not much else. Boy, was I wrong!"

Robert Cox: When one is looking for aberrations, they are seen. The many famous observers who have used achromatic refractors for their observations would probably disagree with the experts' comments on their prized lenses. But we all know that refractors suffer from chromatic aberration, and better systems are on the way.

For example, I recently had the opportunity to test a 6-inch f/12 apochromat made by Roland Christen at Astrofest 87. The view of Jupiter, when it had reached an altitude above ground air currents, was indeed impressive. The planet presented a clear, sharp edge with a high contrast view of surface features. Not one person viewing reported seeing any trace of color around the edges of the object. I also used a Christen 92mm f/7 lens, and even with a 4mm eyepiece, the lens presented an image of Jupiter with no trace of color at the edge.

How much better could the image be? The experts see room for improvement. Tests for practical and normally acceptable amounts of residual color should be made under conditions that approximate practical observing conditions for the instrument to be valid.

Of course, when one runs computer raytraces on lenses, there is always residual color. Interesting things can happen when one compares a computer analysis of a telescope design with field observations. With Newtonian reflectors, for example, it is generally accepted that the coma computed can be reduced to about one-third that expected because the outermost portions of the coma blur are too faint to see.

I suspect that if someone determined what is actually visible versus what the raytrace programs tell us we should see in apochromatic lenses, it would shed light on the conflicting reports one hears. Using a magnification of 140 per inch of aperture, as these optical experts did on the Gregory apo is going to extremes. They were looking for color residuals, so their observations are not applicable to most amateur observing.

The question of how much color is present in apochromatic lenses and how important its visibility is for the amateur is a subjective situation. Even a well-made apochromat may have some residual color, but it may be so low as to take an expert under extreme test conditions to see it.

Lastly, one should not forget, in evaluating refracting systems, that high-quality TCT reflectors may still be the least expensive way to attain total freedom from color.

Blue Pages

Classified Product Directory

ALUMINIZING & COATING

Evaporated Metal Films .....701 Spencer Road, Ithaca, NY 14850
(607) 272-3320

BOOKS/PAMPHLETS/INFORMATION

Willmann-Bell, Inc.....P.O. Box 3125, Richmond, VA 23235
(804) 320-7016

ATTENTION!

PLANETARY, LUNAR, DEEP-SKY OBSERVERS, ASTROPHOTOGRAPHERS

Quality Optics Since 1979 For the Discriminating Amateur and Professional Astronomer

Newtonian and Cassegrain Optics
6" to 24"

Refiguring • Aluminizing Service

Over 25 Years Experience

1987 Complete Optics Catalog, Send $1.00 U.S.
$2.00 Canada or Foreign, in U.S. Currency

Enterprise Optics
P.O. Box 413, Dept. A.
Placentia, CA 92670
(714) 524-7520

DRIVE ELECTRONICS

Lumicon.....2111 Research Dr., Suite 5, Livermore, CA 94550
(415) 447-9570

EYEPIECES

Coulter Optical Co.....54121 Pinecrest Rd., Idyllwild, CA 92349
(714) 659-2991

Lumicon.....2111 Research Dr., Suite 5, Livermore, CA 94550
(415) 447-9570

Manitoba Museum Shop.....190 Rupert Ave., Winnipeg, Manitoba,
R3B ON2, CANADA (204) 956-2830

Meade Instruments Corp.....1675 Toronto Way, Costa Mesa, CA 92626
(714) 556-2291

Sky Designs.....4100 Felps Dr., Bldg. C, Colleyville, TX 76034
(817) 656-4326

TeleVue Optics, Inc.....20-T Dexter Plaza, Pearl River, NY 10965
(914) 735-4044

FILTERS

Lumicon.....2111 Research Dr., Suite 5, Livermore, CA 94550
(415) 447-9570

Meade Instruments Corp.....1675 Toronto Way, Costa Mesa, CA 92626
(714) 556-2291

MIRROR BLANKS

Sky Designs.....4100 Felps Dr., Bldg. C, Colleyville, TX 76034
(817) 656-4326

Willmann-Bell, Inc.....P.O. Box 3125, Richmond, VA 23235
(804) 320-7016

MIRROR COATINGS

Evaporated Metal Films.....701 Spencer Road, Ithaca NY 14850
(607) 272-3320

A New World Standard in Professional Optics for the Serious Amateur.

In 1984, Meade engineers set out to design the finest eyepieces and Barlow lenses—bar none—ever made available for modern telescopes. Specifications called for an unprecedented order of sophistication. Computer optimized design. Special low dispersion glasses (some not even available until recently). And the very latest in coatings technology. Not surprisingly, the resulting Meade Series 4000 is nothing less than a new performance standard in professional optics. The eyepieces and Barlows you would expect from the World's leading manufacturer of astronomical telescopes for the serious amateur.

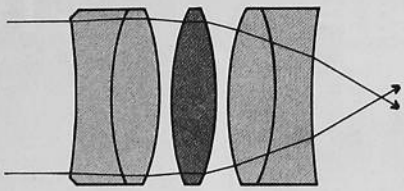
Design Specifications: Meade Series 4000 eyepieces yield the widest possible fields of view, consistent with pinpoint edge-of-field sharpness and long eye relief, and yet with extremely low astigmatism, spherical aberration, and off-axis color. Incorporating 7-layer multi-coatings and edge-blackened optics for optimal image contrast, these sophisticated 5- to 8-element designs permit levels of optical corrections virtually impossible to achieve with eyepieces of fewer elements. The polished chromed-brass barrels are threaded for standard filters, and, where practical (see table), eyepieces and both Barlow lenses are parfocal, allowing eyepiece interchangeability without refocusing.

Eyepiece Groups: Eighteen focal lengths in the three Series 4000 eyepiece groups permit precisely the right eyepiece for any application. Whether your telescope is an f/4 Newtonian, an f/10 Schmidt-Cassegrain, or an f/16 refractor, its performance will benefit by using these incredible oculars:

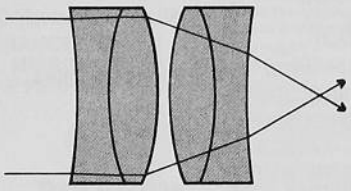
Super Plössls: With 5 optical elements rather than the traditional 4, Meade Super Plössls provide a 40% improvement in corrections for chromatic aberration and edge-distortions over any other premium Plössls. Best for general observing at moderate cost, the Super Plössl eyepieces are perfect optical complements for the Series 4000 air-spaced Barlows, below. Try the 56mm on your 8" Schmidt-Cassegrain for an actual field of over 1.4° at 36X!

Super Wide Angles: These 6-element eyepieces, with their 67° fields, offer exquisite wide-angle images at low to medium powers, ideal for star fields, galaxies, and other deep-space phenomena. Focal lengths with 1¼" barrels yield extremely high-resolution, high-power lunar and planetary images when combined with one of the Series 4000 Barlows.

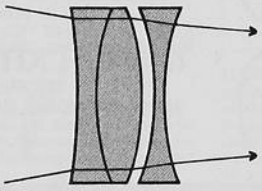
Ultra Wide Angles: The ultimate in modern eyepieces, Meade 8-element Ultra Wide Angles permit extreme image fidelity and sharpness over an amazing 84° apparent field: for moderate to high power applications, no other eyepieces come close. A magnificent optical match with Schmidt-Cassegrains and fast Newtonians.



Meade 5-element Super Plössl design: the central lens element enables significant reductions in chromatic aberration and edge-distortions over other premium Plössl designs.



Other premium Plössls: include only the traditional 4-elements.



Meade Series 4000 Barlows: 3 elements, air-spaced, instead of the standard 2 non-air-spaced elements.

Series 4000 Eyepieces and Barlows

Super Plössls (5-elements)	APPARENT FIELD	BARREL DIA.	PARFOCAL
6.4mm	52°	1¼"	Yes
9.7mm	52°	1¼"	Yes
12.4mm	52°	1¼"	Yes
15mm	52°	1¼"	Yes
20mm	52°	1¼"	Yes
26mm	52°	1¼"	Yes
32mm	52°	1¼"	Yes
40mm	44°	1¼"	No
56mm	52°	2"	No
Super Wide Angles (6-elements)			
13.8mm	67°	1¼"	Yes
18mm	67°	1¼"	Yes
24.5mm	67°	1¼"	Yes
32mm	67°	2"	No
40mm	67°	2"	No
Ultra Wide Angles (8-elements)			
4.7mm	84°	1¼"	Yes
6.7mm	84°	1¼"	Yes
8.8mm	84°	1¼" & 2"	Yes
14mm	84°	1¼" & 2"	No
Barlow Lenses (3-elements, air-spaced)			
#140 2X Telenegative Amplifier		1¼"	Yes
#142 2.8X Telenegative Amplifier		1¼"	Yes

Meade 2" Mirror Diagonal: For attachment to Schmidt-Cassegrain telescopes, the 2" Mirror Diagonal permits use of Series 4000 eyepieces with 2" barrels. The 1/10-wave-flat Pyrex mirror, manufactured at the Meade Costa Mesa optical facility, is multi-coated with enhanced aluminum for maximum reflectance. An adapter for 1¼" eyepieces is included.

Where To Buy: Meade Series 4000 eyepieces and Barlows are available from over 600 authorized Meade dealers in the U.S.A. and Canada. Call us toll-free (see below) for your nearest dealer.

Prices: Notwithstanding their performance standards and optical sophistication, Meade Series 4000 eyepieces and Barlows are priced very competitively with other premium oculars and Barlows.

Series 4000 Barlow Lenses: The most sophisticated Barlows ever developed for commercial telescopes, these 2X and 2.8X Telenegative Amplifiers include 3-element, air-spaced, multi-coated optics, unmatched in image resolution and color correction. Both models optically complement the Series 4000 eyepieces, while significantly enhancing the performance of other eyepieces as well.

Warranty: All Series 4000 systems are covered by the Meade Limited Lifetime Warranty—the most extensive in the industry. See the Meade catalog for details.

Meade®: First in Eyepieces too.

New 1986 Meade General Catalog 86-R: $3.00

Just-published, the new Meade 1986 General Catalog includes complete information on the full range of Meade astronomical products, along with a supplement on **"How To Choose Your Eyepieces."** Send $3.00 for your copy.

U.S. and Canada Dealer Locations & Assistance

For your nearest Meade dealer location, or for free telescope information and assistance, call Meade Instruments **toll-free** from anywhere in the continental U.S.A., (except Calif.):

1-800-854-7485

From all other areas, including California, call direct: **(714) 556-2291**

© 1986

Meade Instruments Corporation
1675 Toronto Way, Costa Mesa, Calif. 92626 □ (714) 556-2291

8X50 Finders

Right Angle With Straight Adapter

Brand New!

Original equipment on SC8's prior to Polaris finders. Classic Black.
Mounting brackets: Newtonians - $22.50
C8/2080 (specify) - $37.50, or make your own.
VISA/MC/Check.

Only **$59.95**

Meade Closeout!
20mm ERFLE
1-1/4" Research Grade, with a 65° Apparent Field!
$49.50

Ideal for...
- "First" Telescope
- Guidescope
- Parts

Complete with 6X30 Finder, 1-1/4" 25mm K, 5" Aperture, 1000mm F.L. (yet only 19" long), Smooth 1-1/4" Focuser, Stable Tabletop Tripod

$189.95

FREE! "Low-Cost"™ TELESCOPE BROCHURE

astro-tech
101 WEST MAIN ■ P.O. BOX 2001
ARDMORE, OKLAHOMA 73402
405/226-3074

MIRRORS — CUSTOM MADE

Coulter Optical Co.....54121 Pinecrest Rd., Idyllwild, CA 92349 (714) 659-2991

Enterprise Optics.....P.O. Box 413, Placentia, CA 92670 (714) 524-7520

MIRRORS — DIAGONALS

Coulter Optical Co.....54121 Pinecrest Rd., Idyllwild, CA 92349 (714) 659-2991

Lumicon.....2111 Research Dr., Suite 5, Livermore, CA 94550 (415) 447-9570

Meade Instruments Corp.....1675 Toronto Way, Costa Mesa, CA 92626 (714) 556-2291

Enterprise Optics.....P.O. Box 413, Placentia, CA 92670 (714) 524-7520

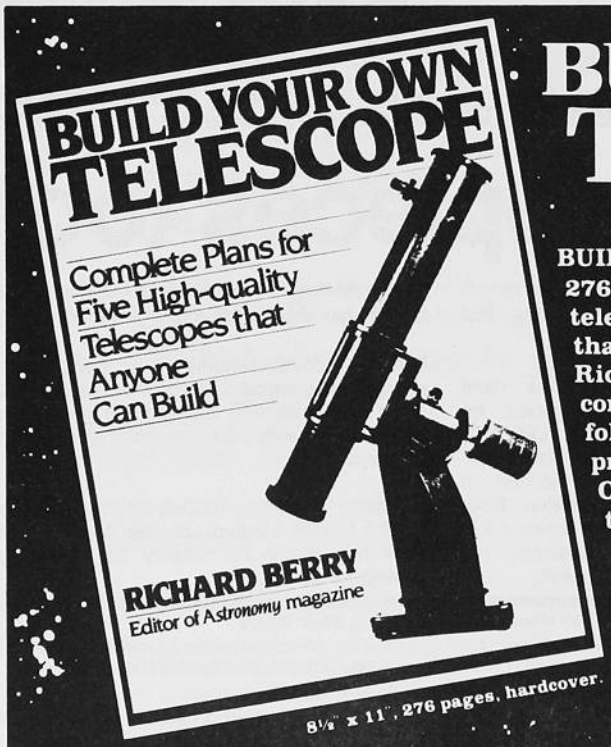
MIRRORS — FLATS

Coulter Optical Co.....54121 Pinecrest Rd., Idyllwild, CA 92349 (714) 659-2991

Lumicon.....2111 Research Dr., Suite 5, Livermore, CA 94550 (415) 447-9570

MIRROR KITS

Willmann-Bell, Inc.....P.O. Box 3125, Richmond, VA 23235 (804) 320-7016



8½" x 11", 276 pages, hardcover.

$24.95
#30124

BUILD YOUR OWN TELESCOPE

By TM Editor Richard Berry

BUILD YOUR OWN TELESCOPE is a new, informative, 276-page book that shows you how to make your own telescope – at far less cost and with less time and effort than you ever imagined! By TELESCOPE MAKING'S Richard Berry, BUILD YOUR OWN TELESCOPE features complete plans for five telescopes, along with easy-to-follow, step-by-step instructions and photos. For these projects, you'll need no special tools, and BUILD YOUR OWN TELESCOPE will tell you where to obtain all the components needed!

BUILD YOUR OWN TELESCOPE includes introductory chapters on how telescopes work, and discusses telescope optics, mountings, and accessories. And for a challenging project, there are chapters on grinding, polishing, and testing telescope mirrors!

Build these telescopes!

- 10" f 6 Newtonian
- 6" f 8 Dobsonian Reflector
- 6" f 8 Equatorial Reflector
- 6" f 15 Refractor
- 4" f 10 Equatorial Reflector

To order, send to DEPT. 4596, TELESCOPE MAKING, 1027 North Seventh St., Milwaukee, WI 53233. Include for postage and handling: U.S. $1; foreign $1.50. Wisconsin residents add 5% sales tax.

LUMICON

HIGH PERFORMANCE TELESCOPE PARTS

ASTROPHOTO OF THE MONTH

Crab Nebula M-1 in Taurus. The Crab Nebula is seen best visually with a LUMICON DEEP-SKY Filter. Photo by David Healy using a LUMICON Giant EASY-GUIDER and LUMICON hypered 2415 film. 33 min. exposure, Celestron-14 at f/6.

20mm NAGLER

New 2" eyepiece with 82° field $295

TELE VUE™ EYEPIECES USE THE BEST!!

ALL IN STOCK

Renaissance 4" f/5.5. Telescope	$1395
7.4, 10.4, 13, 17, 21, 26mm Plossl, 50°	$95
1.8X or 2.5X Tele Vue Barlow Lens	$95
32mm Plossl, widest true field in 1¼"	$110
55mm 2" Plossl, widest possible field	$190
15mm Wide-Field, 1¼" eyepiece, 65°	$130
19mm Wide-Field, 1¼" eyepiece, 85°	$145
24mm Wide-Field, "superb," 65°	$160
32mm Wide-Field, 2" eyepiece, 65°	$230
40mm Wide-Field, "awesome," 65°	$295
4.8mm Nagler, 82° field	$150
7mm Nagler, 1¼" eyepiece, 82° field	$185
9mm Nagler, 82° field, "the best"	$225
11mm Nagler, 82° field, 1¼" or 2"	$240
13mm Nagler, 82° field, 1¼" or 2"	$250
20mm Nagler, 82° field, 2" eyepiece	$295

48mm COLORED FILTERS

Upgrade to 48mm filters! All are multicoated

UV, Green, Yellow, Orange, Red	$18 each
48mm H-Alpha Pass (640nm cut-off)	$35
48mm Minus Violet (420nm cut-off)	$29
48mm High perform blue, 90% trans	$35
Central Star Filter (blue tri-color) 340-470nm bandpass	$35
UV-370 U-Band, 320-420nm bandpass	$35
48mm Polarizer (2 make variable density)	$18
Set 9 ea. 48mm filters ($259 list)	$195
2"/1¼" adapter threaded for 48mm filters	$20

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photography with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	H-Alpha	(MV)
46, 48, 49mm	$35.00	$29.00
52, 55, 58, 62mm	$45.00	$35.00
67, 72, 77mm	$52.00	$45.00
82mm	$55.00	

Hypered 2415 film, 36 exp . . . $10.95 . . . 3/$29

NEW! ENHANCED SILVER DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 3.1" enhanced silver diagonal mirrors & 2" star diagonal.
The new LUMICON diagonal mirrors have a special enhanced silver coating with a protective overcoating for long life. Visible reflectivity is 98-99% compared to 86-89% for standard aluminum coated mirrors. The extra 10-12% transmission is like adding an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32"	$29.95	1.52"	$34.50	1.83"	$39.50
2.14"	$49.50	2.60"	$65.00	3.10"	$89.50
4.25"	$149.50				

ENHANCED SILVER STAR DIAGONAL

90° star diagonals with above enhanced silver mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror)	$89.50
2" (1.83" mirror)(see photo above)	$145.00

OXYGEN-III FILTER

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

The ultimate in filter performance! The Lumicon Oxygen-III Filter has a contrast twice as high as the high performance Lumicon UHC Filter™. Use the Oxygen-III Filter for observing the very faintest planetary and diffuse emission nebulae. Also gives incredible views of bright nebulae (like M-27, M-17, etc.) from urban locations. Bandpass is 11nm, transmission is 90% for both O-III lines at 496nm and 501nm.

Filter Type	1¼"	48mm
Lumicon Oxygen-III	$99.50	$199.50
Lumicon UHC	$99.50	$199.50
Lumicon Deep-Sky	$79.50	$119.50
Set UHC and Oxygen-III	$190.00	$380.00

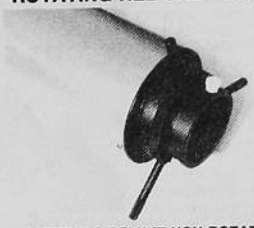
NOTE: The Oxygen-III Filter is not a substitute, but a compliment to the UHC Filter. **1 year guarantee:** You must see nebulae with the OIII filter that are **invisible** without a filter.

NEW ADJUSTABLE PIGGYBACK MOUNT

LUMICON has just designed a new adjustable piggyback mount ideal for all telescopes of 8-14" aperture. It has **both** vertical and sideways adjustment to allow optical alignment. It was designed to allow mounting of the LUMICON SUPER-FINDER on C-8, C-14, etc., but is ideal for any telephoto lenses or small telescopes.

Deluxe Piggyback Mount (State Telescope Type)	$45.00
LUMICON 12x80mm SUPER-FINDER	$170

LOW PROFILE NON-ROTATING HELICAL FOCUSER



LUMICON® DELUXE NON-ROTATING HELICAL FOCUSER on a SUPER-FINDER

LUMICON has just designed a deluxe smooth helical focuser with non-rotating 2" I.D. eyepiece holder. It has a vertical travel of 1¼" and a very low profile, only 1¼" high. It is CNC machined, black anodized, and a perfect match to a LUMICON Newtonian EASY-GUIDER.

Select your desired base-plate shape!
Flat, 7" OD, 9½" OD, 12½" OD, 16" OD, 20" OD, SUPER-FINDER base plate.

LUMICON Deluxe Helical Focuser	$79.50
3 handles (see photo)	$12.95
Helical focuser with 3 handles	$92.45
2"/1¼" adapter w/48mm filter threads	$20.00
2" LUMICON EASY-GUIDER	$139.50

PROTECTIVE DUST COVERS

Protective plugs (left), vinyl dust covers.
Protect your valuable telescope optics, eyepieces and accessories with these black vinyl covers. Add $1 shipping. Deduct 10%, 2 or more sets.

1¼" O.D. plug, seals focuser	4/$2		
2" O.D. plug	2/$2	3½" O.D. plug	$1.50
1¼", 1⅜"	3/$2	7½"	$8
1½"	2/$2	9½", 10.4"*	$12
2"	2/$2	12½", 12⅞"*	$15
3½", 4½"	$5	16"*	$20
5½"	$6	19" (DS-16)	$27

*Fits Odyssey

MAKE YOUR OWN ASTROGRAPH

FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15X film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$295.00**

MODEL 600 HYPER-KIT (See Photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates . **$350.00**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller **$595.00**

Temperature controller for any HYPER-KIT	$59.50
Electric Vacuum Pump	$280.00

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms fo bright guide-starts. *Specify Camera and Telescope type.*
U.S. Patent # 4,448,500

NEWTONIAN EASY-GUIDER™

Full aperature. Installs in secs. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER	$169.50
3X Relay Diagonal (see photo)	$79.50
Illuminated reticle eyepiece system	$79.50
Guider for Hasselblad **$350,** Mamaya 645	$159

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Dynamax-8. Includes 50mm achromatic lens for f/5.8 operation-3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER	$225.00
Adapter for Hasselblad **$185,** Mamaya 645	$159

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER	$395.00
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20)	add $99.95
Adapter for Hasselblad **$195,** Mamaya 645,	$96

WHAT DO YOU NEED?

1. **Illuminated reticle eyepiece** . . . $79.50
Lumicon 12mm eyepiece system has adjustible L.E.D. illumiation, dual crosslines, battery pack.
2. Cable release for long exposures . **$9.95**

3. **LUMICON Quartz Drive Corrector $219**
Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 40Hz/80Hz variable output controls telescope drive. 60Hz Quartz reference ±12VDC Declination control output. Both 110VAC and 12VDC input for home or field use. Declination reverse switch for Newtonians.

Declination motor (state telescope)	$70
NEW Deluxe Digital Qtz. Drive Correc.	$298

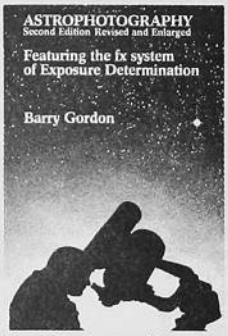
HYPERSENSITIZED FILM

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.).

Film Type, 35mm	Exposures	Price
2415, Ultra-fine B&W, red sens.	36	$10.95
SR1600, fastest of all, color neg	24	$12.95
Konica SR200, fine grain color neg	12	$9.95
3M 1000, fastest slide film	20	$12.95
Fujichrome RD100, fine grain slide	24	$12.95
5072, color slides from neg	36	$6.95
D-19 B&W Developer	1 gal.	$6.95

LUMICON®

2111 Research Drive #5T Livermore CA 94550
For phone orders please call (415) 447-9570
LUMICON Products catalogue $2.
Foreign orders add $8 ($20 for HYPER-KITS)
California Residents add 6% tax.
Prices subject to change w/o notice.



Dennis di Cicco wrote in the December 1983 *Sky and Telescope* "Perhaps the most innovative section of the book is Gordon's approach to determining the correct exposure. He has developed what he calls the "*fx* system," whereby the basic elements of film speed, exposure duration, and f/number are assigned simple numerical values. Each scene, whether a daytime landscape, the Moon's surface, or Jupiter, is given an *fx* value for the appropriate exposure. It is a simple matter to add the appropriate values of different elements to arrive at the correct *fx* for the scene...I was impressed with Gordon's *fx* values for photographing objects like M27 and M57. Working through the simple formula described earlier, I found that some of my best exposures correspond closely to *fx* values recommended in the book... Overall, *Astrophotography* is an excellent book with a lot to offer." Now this 2nd edition has been revised and enlarged with more than 75 photographs (many full page), 32 tables and 7 line drawings. If you are new to astrophotography this book will get you going with good results right from the start.

☐ **Astrophotography—2nd Edition,** Gordon **18.95**

NEW FRONTIERS AND TEXTS IN ASTRONOMY

☐ **Astronomy from Space** Cornell/Gorenstein **17.50**
☐ **Maxwell on Saturn's Rings** **27.50**
☐ **Nature of Matter** Mulvey **15.95**
Relativistic Astrophysics
☐ **Vol. 1** Stars and Relativity **55.00**
☐ **Vol. 2** Structure & Evol. of Universe **80.00**
☐ **The Physical Universe** Shu **32.00**
☐ **Theoretical Cosmology** Raychaudhuri **29.00**
☐ **Search for Gravity Waves** Davies **17.95**
☐ **Gravitation & Space Time** Ohanian **24.95**
☐ **Cosmic Discovery** Harwit **26.50**
☐ **Phys. of Interstellar Medium** Dyson **31.95**
☐ **Redshift Controversy** Field **29.95**
☐ **Cosmology** Harrison **32.50**

SUN

☐ **The Sun, Our Star** Noyes **20.00**
☐ **Wooden Sundials** Stoneman **2.95**
☐ **The Sun** Nicolson **16.95**
☐ **Sunspots** Bray/Loughhead **9.50**
☐ **Eclipse** Brewer **6.95**
☐ **Sundials** Mayall/Mayall **12.95**
☐ **New Sun, Solar Results from Skylab** NASA **21.00**
☐ **Sundials** Waugh **4.00**

PHOTOMETRY

☐ **Communications of IAPPP** Vol. 1-2 and 3, 4, 5, 6, 16, 17, 18, 19, 20, 21, 22, 23, 24 ..... **4.50**
☐ **Software for Photometric Astro** Ghedini **26.95**
☐ **UBVRIJKL Photometry of Bright Stars** **18.95**
☐ **Photoel. UBV Obs. of RR Lyrae Variable Stars** Johnson **4.50**
☐ **Astro. Photometry** Henden/Kaitchuck **29.95**
☐ **Cat. of Photoel. Mag & Colours of Visual Double & Multiple Systems** **30.00**
☐ **Solar System Photometry Handbook** Genet **17.95**
Advances in Photoelectric Photometry
☐ **Vol. 1** Wolpert/Genet **23.95**
☐ **Vol. 2** Wolpert/Genet **23.95**

RADIO ASTRONOMY

☐ **Jodrell Bank Telescopes** Lovell **19.95**
☐ **An Amat. Radio Telescope** Swenson **9.95**
☐ **Solar-Amateur Radio Astronomy** Lichtman **12.50**
☐ **Amat. Radio Astro. Circuit Cookbook** **12.50**
☐ **Microwave Radio Astro.—An Amat. Intro.** **20.00**
☐ **Radiotelescopes** Christiansen/Hogbom **59.50**

ALL PRICES SUBJECT TO CHANGE WITHOUT NOTICE.

Don't see what you need? Send for a large format **32 page catalog** listing nearly 1500 books, telescope making supplies, and other astronomy related items. Send $1.00 for First Class postage in U.S.A. and Foreign Sea Mail, or $5.00 for Foreign Air Mail. **We include a copy of our catalog with each order. Foreign Customers–shipping charges extra; write for free Proforma Invoice detailing costs.**

☐ ☐ ☐ ☐ SUB TOTAL $ _____
HANDLING 1.00
MC INTERBANK NO | CARD EXPIRES MO YR
VA: + 4% Tax _____
CHARGE CARD NUMBER
TOTAL $ _____
CARD HOLDER NAME (PLEASE PRINT!)
CARD HOLDER SIGNATURE
NAME
ADDRESS
CITY STATE ZIP

ADVANCED TELESCOPE MAKING TELESCOPE TECHNIQUES
Edited by
Allan Mackintosh with G.K. Hawkins and F.I. Baar

Starting in 1957, and continuing for nearly 20 years, Allan Mackintosh directed the publication of the "Circulars" for the Maksutov Club. First formed to make a mass purchase of corrector blanks the club soon expanded to become a forum for advanced telescope making techniques. By the time "Circulars" ended when Mackintosh retired to his native England, they totaled nearly 1800 closely typed pages.

Following Mackintosh's suggestion the most significant articles from the circulars have been arranged into two volumes — *Optics and Mechanical*, where together they total 17 chapters of 143 articles taking up more than 600 typeset pages with over 450 illustrations.

What will you find in these books? First, the coverage is not elementary—most of the author's who submitted were accomplished at working under the extreme conditions met within making a Mak (very short radii of curvature and very tight tolerances on thickness, etc.). Second the information is detailed—there was little constraint on the length of individual submissions—if the author had something to say he usually got one, two or even three "Circulars" to tell his story. For example, Norman James Fiberglass Telescope Making Techniques (and his Porter-like drawings) are so detailed that it took 4 circulars to complete. Similarly, Paul Jones article on Optical Glass Edging is the most detailed than you will find in print.

☐ **Volume 1—Optics** **$19.95**

Chapters: 1. Figuring, etc., 2. Testors and Testing, 3. Optical Theory, 4. Telescope Designs and Designs 5. Spectrohelioscopes, 6. Interferometers, 7. Calculator Programs for Telescope Makers.

☐ **Volume 2—Mechanical** **$19.95**

Chapters: 1. Glassworking-Grinding Tools, 2. Curve Generators, Generating, Edging, Etc., 3. Small Lens Work, 4. Accessories for Glass Working, 5. Grinding and Polishing Machines, 6. Making and Testing Flats, 7. Telescope Construction, 8. Telescope Accessories, 9. Photography, 10. The Telescope Maker's Workshop.

ATLASES AND CATALOGUES

☐ **Atlas of Galactic Nebulae, Part 1** Neckel/Vehrenberg **65.00**
☐ **Atlas Designed to Illus. Geography of Heavens** Burritt **22.75**
☐ **Yale Bright Star Catalogue** Hoffleit **45.00**
☐ **Supplement to Yale Bright Star Cat.** **18.00**
☐ **Appar. Places of Fund. Stars 1985 or 86** **35.00**
☐ **NGC, Index Cat., 2nd Index Cat.** **24.95**
☐ **Sarna Deep Sky Atlas** Sarna **29.95**
☐ **Cape Photographic Durchmusterung Atlas** Rappaport **450.00**
☐ **Catalog of Central Stars of True and Possible Planetary Nebulae** Comp. I, II, III **35.00**
☐ **Sky Atlas 2000.0 Deluxe** Tirion **34.95**
☐ **Field Edition** (Unbound-white stars) **15.95**
Sky Catalogue 2000.0
☐ **Vol. 1.** Stars to Mag. 8 ..... **29.95**
☐ **Vol. 2.** Dbl., Var. Stars and Non-Stel Objs. **29.95**
☐ **Atlas Borealis** Becvar **49.95**
☐ **Atlas Australis** Becvar **49.95**
☐ **AAVSO Variable Star Atlas** Scovill **59.95**
☐ **Mag 6 Atlas** **16.95**
☐ **Atlas of Andromeda Galaxy** Hodge **60.00**
☐ **Galaxies** Ferris **16.95**
☐ **Small Magellanic Clouds** Hodge/Wright **65.00**
☐ **Atlas of Mars** NASA **15.00**
☐ **Hubble Atlas of Galaxies — Cloth** **29.00**
☐ **Messier Album** Mallas/Kreimer **16.95**
☐ **Rectified Lunar Atlas** Whitaker **50.00**
☐ **Cat. of Star Clusters & Assoc.** w/Sup. **115.00**
☐ **Syst. for Open Star Clusters & The Galaxy Atlas of Open Star Clusters** Alter **72.50**
☐ **Catalogue of Cometary Orbits** Marsden **11.95**
☐ **Emission Line Survey of Milky Way** **18.00**
☐ **Ariz.—NASA Atlas of Infrared Solar Spectrum** **18.95**
☐ **Rev. Shapley-Ames Cat.** Sandage/Tammann **30.00**
☐ **SAO Star Catalogue** 4 vol. **60.00**
☐ **Reference Catalogue of Bright Galaxies** **35.00**
☐ **Catalogue of Galaxies and Cluster of Galaxies** Zwicky Vols. 2 to 6 each **19.50**
☐ **Handbook of Constellations** 5th ed. Vehrenberg **34.95**
☐ **Atlas of Deep Sky Splendors** Vehrenberg **39.95**
☐ **Cambridge Deep Sky Album** **23.95**

REFERENCE

☐ **Floppy Almanac for IBM-PC 1986 U.S. Naval Observatory** **20.00**
☐ **Floppy Almanac for IBM-PC 1987 U.S. Naval Observatory** **20.00**
☐ **Calendar Conversions by Julian Day Number** Harvey **14.00**
☐ **Astronomical Almanac 1986 USN** **25.00**
☐ **Astronomical Almanac 1987 USN** **18.00**
☐ **Almanac for Computers 1986 USN** **3.50**
☐ **Almanac for Computers 1985 USN** **5.50**
☐ **Planetary and Lunar Coord. 1984-2000** **15.00**
☐ **Canon of Solar Eclipses –2003 +2526** **90.00**
☐ **Canon of Lunar Eclipses –2002 +2526** **35.00**
☐ **Ephemeris of the Moon 1800-2000** MacCraig **7.75**
☐ **200 Year Ephemeris 1800-2000** MacCraig **15.00**
☐ **Astro. Tables of Sun, Moon & Planets** **19.95**
☐ **First Dict. of Nomenclature of Celestial Objects (Solar System excl.)** **25.00**

HANDBOOKS

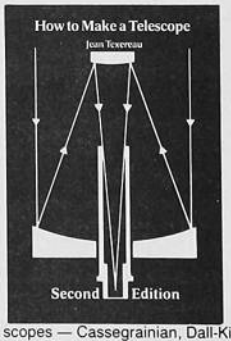
☐ **How to Use an Astronomical Telescope** Muirden **21.95**
☐ **Amateur Astronomers Handbook** 4th ed. Sidgwick **10.95**
☐ **Field Guide to Stars & Planets** Menzel/Pasachoff **12.95**
☐ **Astronomical Objects for Southern Telescopes** Hartung **17.95**
☐ **The Light-Hearted Astronomer** Fulton **6.95**
☐ **Wonders of the Sky** Schaaf **6.95**
Burnham's Celestial Handbook
☐ **Vol. 1.** Andromeda thru Cetus **11.95**
☐ **Vol. 2.** Chamaeleon thru Orion **11.95**
☐ **Vol. 3.** Pavo thru Vulpecula **12.95**
Webb Soc. Deep-Sky Observer's Handbook
☐ **Vol. 1.** Double Stars 2nd ed. **13.95**
☐ **Vol. 2.** Planetary & Gaseous Nebulae **10.95**
☐ **Vol. 3.** Open & Globular Clusters **14.95**
☐ **Vol. 4.** Galaxies **16.95**
☐ **Vol. 5.** Clusters of Galaxies **16.95**
☐ **Exploring the Moon** Cherrington **11.95**
☐ **Observers Handbook 1986** RASC **9.00**
☐ **Astronomy: A Handbook** Roth **24.95**
☐ **Obs Astro for Amateurs** Sidwick, 4th ed. **8.95**
☐ **Proj & Demo in Astro** Tattersfield **42.95**
☐ **Astro with Binoculars** Muirden **13.95**
☐ **Observing Visual Double Stars** Couteau **8.95**

STARS AND GALAXIES

☐ **Dark Matter in Open Clust** Wallenquist **25.00**
☐ **Magellanic Clouds** Muller **26.00**
☐ **Intro Stellar Struc** Chandrasekhar **8.95**
☐ **Star Formation** Jong/Maeder **24.00**
☐ **Language of the Stars** Kopal **36.50**
☐ **Astrophysics Gaseous Nebulae** Osterbrock **35.95**
☐ **Dk. Nebulae—Globules—Protostars** Lynds **12.50**
☐ **Stellar Atmospheres** Mihalas **42.95**
☐ **Struc & Evol of Stars** Schwarzschild **6.00**
☐ **Stars: Structure & Evolution** Tayler **12.00**

This book is the first how-to-do-it book for microcomputer control of small- and medium-sized telescopes. It devotes entire chapters to control theory, motors and their controllers, angle sensors, astronomical and mechanical corrections. The authors have sought to make this book a complete, single source of information and it is based upon their hands-on experiences with automated telescopes. One of the systems described does fully automatic photometric measurements of over 100 different stars each clear night. Over 140 illustrations, schematics, and flow diagrams provide all the detail you need to duplicate the systems described or to begin your own unique design. Includes complete software listings in Apple BASIC and BASIC09.

☐ **Microcomputer Control of Telescopes,** Trueblood and Genet **19.95**



For nearly 30 years the first edition of this book has been considered by many to be the best guide to making a Newtonian Telescope. The author takes you step-by-step through the process of grinding, polishing, testing, and installing your mirror in a tube on either an altazimuth or equatorial mount. This new edition with over 300 more pages now has entire chapters on making a Cassegrainian, optical windows, equatorial mounts, computer programs in generic BASIC for the reduction of Foucault test data and the design of two mirror telescopes — Cassegrainian, Dall-Kirkham, Pressmann-Carmichel, and Ritchey-Chretien. Also included are comprehensive bibliographies from *Sky and Telescopes* "Gleanings", *Scientific American* and *Telescope Making* magazines. *Astronomy* magazine's reviewer said "...the book has that same feeling of total mastery as the original...With this book, you have every chance of building what Texereau calls "a telescope that is optically beyond reproach".

☐ **How to Make a Telescope—2nd Edition,** Texereau **19.95**

Willmann–Bell, Inc.

P.O. Box 35025
Richmond, Virginia 23235
United States of America

Monday–Saturday
9 A.M. – 9 P.M. E.S.T.
☎ (804) 320-7016

Serving Astronomers Worldwide
Since 1973

77° 35′ 41″ W

MIRRORS — OFF-THE-SHELF

Coulter Optical Co.....54121 Pinecrest Rd., Idyllwild, CA 92349
(714) 659-2991

Enterprise Optics.....P.O. Box 413, Placentia, CA 92670
(714) 524-7520

Meade Instruments Corp.....1675 Toronto Way, Costa Mesa, CA 92626
(714) 556-2291

MOUNTINGS — COMPLETE

Lumicon.....2111 Research Dr., Suite 5, Livermore, CA 94550
(415) 447-9570

MOUNTINGS — PARTS

Tom Osypowski.....11065 Peaceful Valley Rd., Nevada City, CA 95959
(916) 265-3183

OPTICAL ABRASIVES — BULK

Willmann-Bell, Inc.....P.O. Box 3125, Richmond, VA 23235
(804) 320-7016

Meade Instruments Corp.....1675 Toronto Way, Costa Mesa, CA 92626
(714) 556-2291

Sky Designs.....4100 Felps Dr., Bldg. C, Colleyville, TX 76034
(817) 656-4326

OPTICAL TEST EQUIPMENT

Coulter Optical Co.....54121 Pinecrest Rd., Idyllwild, CA 92349
(714) 659-2991

TELESCOPE ACCESSORIES

Astro-Tech.....101 West Main, P.O. Box 2001, Ardmore, OK 73402
(405) 226-3074

Berger Bros.....209 Broadway (Rte. 110), Amityville, NY 11701
(516) 264-4160

Celestron International.....2835 Columbia St., Torrance, CA 90503
1-800-421-1526, (213) 328-9560

Lumicon.....2111 Research Drive, Suite 5, Livermore, CA 94550
(415) 447-9570

Manitoba Museum Shop.....190 Rupert Ave., Winnipeg, Manitoba,
R3B ON2, CANADA (204) 956-2830

Meade Instruments Corp.....1675 Toronto Way, Costa Mesa, CA 92626
(714) 556-2291

TELESCOPE PARTS

Kenneth F. Novak & Co.....Box 69T, Ladysmith, WI 54848
(715) 532-5102

Meade Instruments Corp.....1675 Toronto Way, Costa Mesa, CA 92626
(714) 556-2291

TeleVue Optics, Inc.....20-T Dexter Plaza, Pearl River, NY 10965
(914) 735-4044

LIGHT EMITTING DIODE ILLUMINATION

- Ultra-bright LED penlights offer...
- Greatly extended battery life (up to 40 times longer than with incandescent bulb of same brightness)
- Uniform red light (won't impair night vision)
- 100,000 hour lifetime for LED (no bulb to burn out)

– Flashlight bulb replacements also available –

40 hour battery life penlight $6.95
80 hour battery life penlight $7.95
High-efficiency flashlight bulb replacement $3.95
Ultra-high efficiency flashlight bulb replacement (twice the efficiency of above unit) . $4.95

Prices include shipping and handling in the U.S.; penlights include batteries. California residents add 6% sales tax.

DAVID SENSIPER
P. O. Box 63, Harbor City, CA 90710
(213)-325-7827

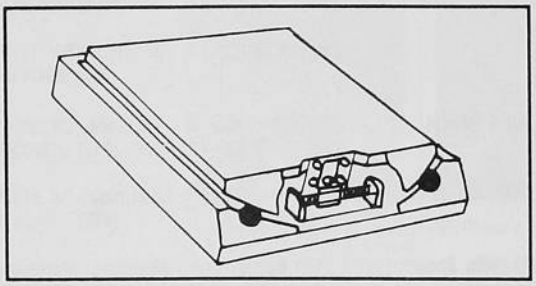
Advertisers! Put your sales message in the magazine for, by, and about serious amateur telescope makers!

5,500 ready-to-buy readers will see the ads in this issue!

For information on advertising, call or write:

TELESCOPE MAKING
Dana-Lynne Terry
Advertising Sales Manager
TELESCOPE MAKING
1027 N. 7th Street
Milwaukee, WI 53233
Call toll-free: 800-558-1544
In Wisconsin and Canada call collect: 414-272-2060

EQUATORIAL PLATFORMS
for Dobsonian Telescopes



- One hour tracking/fast rewind
- Perfect for high power visual observing and group viewing
- Custom made for your latitude
- Available for Dobs up to 17 1/2"
- Prices start at $500.00

for information packet with photos send $2.00 to:

Tom Osypowski
11065 Peaceful Valley Rd.
Nevada City, CA 95959
916-265-3183 (eves.)

TELESCOPE TUBES

Meade Instruments Corp......1675 Toronto Way, Costa Mesa, CA 92626 (714) 556-2291

Pesco Aluminum Tube.....2077 S. State St., Ann Arbor, MI 48104 (313) 761-5110

TELESCOPES, COMPLETE

Berger Bros......209 Broadway (Rte. 110), Amityville, NY 11701 (516) 264-4160

Celestron International.....2835 Columbia St., Torrance, CA 90503 1-800-421-1526, (213) 328-9560

Coulter Optical Co......54121 Pinecrest Rd., Idyllwild, CA 92349 (714) 659-2991

Lumicon.....2111 Research Drive, Suite 5, Livermore, CA 94550 (415) 447-9570

Manitoba Museum Shop.....190 Rupert Ave., Winnipeg, Manitoba, R3B ON2, CANADA (204) 956-2830

Meade Instruments Corp......1675 Toronto Way, Costa Mesa, CA 92626 (714) 556-2291

TeleVue Optics, Inc......20-T Dexter Plaza, Pearl River, NY 10965 (914) 735-4044

The Choice Telescope Makers Make.

Meade® IN STOCK
NEW SERIES 4000 PROFESSIONAL EYEPIECES
- SUPER PLOSSL EYEPIECE 52° APPARENT FIELD OF VIEW
- SUPER WIDE ANGLE EYEPIECE 67° APPARENT FIELD OF VIEW
- ULTRA WIDE ANGLE EYEPIECE 84° APPARENT FIELD OF VIEW

Telrad™

CORRECT IMAGE FINDER $39.99

HIGH SPEED FILM

TRANSPARANCY FILM	ASA
FUJI PRO	50,100,400,1600
AGFA	1000
KODAK	800/1000
3M	1000
PRINT FILM	ASA
FUJI, KONICA	1600
KODAK, AGFA	1000

KODAK TECH-PAN FILM IN STOCK

LUMICON®
FILTERS & ACCESSORIES
IN STOCK

Complete Selection of Cameras and Focusing Screens for Astro Photography

TeleVue™
EYEPIECES
IN STOCK

OPEN 7 DAYS
48 HOUR DELIVERY AVAILABLE

BERGER BROS.
CAMERA EXCHANGE

CALL TOLL FREE
950-1088 (TONE)
264-4160

209 BROADWAY (ROUTE 110) • AMITYVILLE, N.Y. 11701 • (516) 264-4160

Tele Vue

NAGLER TYPE 2
82° FIELD EYEPIECES

These new 8-element designs extend the Nagler concept to impressive new performance levels, while retaining the basic advances of the original Naglers:
—82° apparent field
—Full field correction
—Fast aperture correction

New Features Include:

First, three new focal lengths, 12mm, 16mm, and 20mm extend the concept to unprecedented wide viewing fields.

Second, full exit pupil correction permits comfortable night and day use.

Third, fold-down rubber eyeguards are included for maximum comfort and dark adaptation.

Fourth, relatively lightweight and moderately sized, they also have knurled rubber grip rings for easier handling.

Design Goals

The basic Nagler series has already achieved image correction 10 times better than previous wide angle eyepieces (study in "Telescope Making" titled "The Nagler 13, a Remarkable Telescope Eyepiece"). We felt that trying to extend the apparent field or image correction levels beyond that of the original Nagler series would NOT yield significant practical gains, but that extending the focal lengths WOULD offer enormous potential for spectacular low power, wide-angle viewing. After all, Tele Vue Wide-Field eyepieces have already proved the value of low power 65° viewing with important improvements in image sharpness.

What were the barriers to simply scaling up the original Nagler designs to longer focal lengths?

Two practical limits had to be overcome:

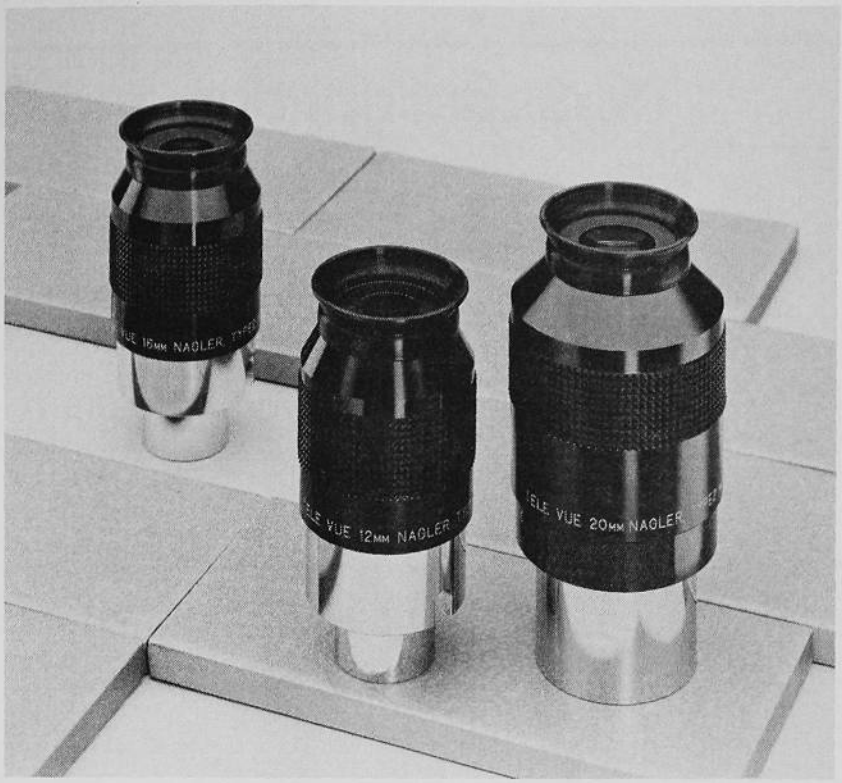
1) Substantial physical size, weight, and cost increases would be impractical.
2) Scaling up exit-pupil aberrations would be unacceptable in our judgement. Although the original Nagler eyepieces provide extremely sharp IMAGES, exit-pupil aberrations require a large (nighttime) eye pupil opening to encompass the full field. For this reason, daytime viewing with the 13mm Nagler is not recommended. Eye positioning is just too sensitive with this design to consider focal lengths longer than 13mm. The 9mm and shorter Naglers don't show this sensitivity.

Nagler Type 2: The design breakthrough!

The design experience gained in developing the patented Plössl, Wide-Field, and Nagler eyepieces resulted in an even more advanced concept: — 8-element, 82° field designs (pat. pend.) with full correction of exit-pupil aberrations that permit the most comfortable viewing ever — night or day! Each model is a unique design, with a tailored eye relief like the 9mm Nagler, yet surprisingly compact, lightweight, and affordable. Extensive computer-aided design efforts and the use of new glass types retained the traditional superb full-field and fast-aperture sharpness. Of course, our pioneering lens edge-blackening, and multi-coating are included for maximum contrast.

A further important contribution to viewing comfort and effectiveness is a fold-down rubber eyeguard. This eliminates stray light and enhances dark adaptation to aid in detecting faint, delicate nebulosity and comets. The eyeguard is a delight on cold nights too.

20mm Nagler Type 2: This has the largest true field in the series, even larger than our 32mm Plössl. Yet this eyepiece, (strictly for 2 inch focusers) is comparable in size and weight to a 13mm Nagler. There's nothing like this 20mm for viewing large deep-sky open clusters, galaxies and nebulae. It gives a 4.5mm exit-pupil with f/4.5 telescopes. Daytime viewing is also simply stunning!



16mm Nagler Type 2: Offers far more true field than the 13mm Nagler, yet is similar to the 11mm in size! Great day or night performance with any telescope.

12mm Nagler Type 2: As superb as the 16mm, but with higher magnification. An excellent alternate to the 13mm or 11mm Nagler, which are preferable where the longer eye relief is of benefit to people who MUST wear eyeglasses to correct severe astigmatism.

The 16mm and 12mm TYPE 2 NAGLERS also work beautifully with Tele Vue Barlows. They both have 1¼" barrels that are parfocal with our other eyepieces and can also be used with 2" focusers.

Tele Vue

20 Dexter Plaza, Pearl River, NY 10965
(914) 735-4044

APPROXIMATE MAGNIFICATIONS WITH TYPICAL TELESCOPES

magnifications are with 1.8x Barlows magnifications are with 2.5x Barlows

Telescope Type		4"f/5.5 Renaissance	6"f/5	8"f/5	6"f/8 5"f/10 (C-5)	10"f/6 13"f/4.5	8"f/10 (C-8)	11"f/10 (C-11)
Telescope F.L. Inches		21.6	30	40	50	60	80	110
F.L. mm		550	762	1016	1270	1524	2032	2794
Barrel Diameter	Type 2 Nagler Eyepiece F.L.	Power						
2"	20mm	28x	38	51	64	76	102	140
		34	48	64	79	95	127	175
1¼"-2"	16mm	62 86	86 119	114 159	143 198	171 238	229 318	314 437
		46	64	85	106	127	169	233
1¼"-2"	12mm	83 115	114 159	152 212	190 265	229 317	305 423	419 582

TM Subscriptions and Renewals

☐ $12 for four issues ($14 foreign) ☐ New Subscription ☐ New Address
☐ $21 for eight issues ($25 foreign) ☐ Renewal

Name _____

Address _____

City _____

State, Zip _____

Your subscription will begin with the next issue published. Payment must accompany order. Foreign subscribers must remit in U. S. funds.

When to renew: Look at your mailing label. This will be your last issue.

700000165500 TMK (TM32) SC
RICHARD BERRY
1027 N 7TH ST
MILWAUKEE WI 53233

TELESCOPE MAKING, Circulation Dept., 1027 N. 7th St., Milwaukee, WI 53233

TM BACK ISSUES AND REPRINTS

At present, all back issues of TELESCOPE MAKING are still available. Order now while quantities last. Remember – the information found in TELESCOPE MAKING does not go out of date!

See TM#20, pages 30 through 34, for our "Index to Back Issues," listing issues #1 through #20, or write to the address below for an updated index.

☐ **Please send me the TM Back Issues I've circled below (note: TM #1 & 2 are printed and bound as one issue and count as one back issue).**

PRICES
TM#1 & 2 - TM#30: $4.00 each ($4.50 each foreign). Or, order 25 or more back issues for only $3.00 each ($3.50 foreign) — a savings of 25%!

#1 & 2	#3	#4	#5	#6	#7	#8	#9	#10
#11	#12	#13	#14	#15	#16	#17	#18	#19	#20
#21	#22	#23	#24	#25	#26	#27	#28	#29	#30

"How to Build Your Own Observatory" contains ideas that will help you build 13 great backyard observatories – from a simple shelter from streetlights to a gleaming garage-top dome. Reprinted articles from TM, 64 pages, paperback.

☐ **Please send _____ copy(ies) of "How To Build Your Own Observatory" at $5.95 each.**

"Build Your Own Telescope" shows you how to make your own telescope at far less cost and with less time and effort than you ever imagined. By TM's editor, Richard Berry, it features complete plans for 5 telescopes, along with easy-to-follow, step-by-step instructions and photos. 276 pages, hardcover.

☐ **Please send _____ copy(ies) of "Build Your Own Telescope" at $24.95 each.**

Include for postage and handling: U. S. $1; (foreign $1.50-books only). Wisconsin residents add 5% sales tax.

Total amount enclosed: $ _____ .

Name _____

Address _____

City _____

State, Zip _____

4588

If you don't wish to damage this copy of your magazine, just send us a photocopy or reasonable facsimile of this order form.

Please allow four to six weeks for delivery of your order. Payment must accompany order. Foreign orders please remit in U. S. funds; overseas orders are sent by surface mail.

TELESCOPE MAKING, Order Department, 1027 N. 7th St., Milwaukee, WI 53233